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P 310.12

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# PHILOSOPHY IN SPORT

MADE

# SCIENCE IN EARNEST.

'Tis not enough that Greek and Roman page,
At stated hours, the sprightly boy engage;
Ev'n in his pastimes he requires a friend,
To warn, and teach him safely to unbend;
And levying thus, and with an easy sway,
A tax of profit from his very play,
T' impress a value, not to be eras'd,
On moments, squander'd else, and running all to waste.

COWPER's *Tirocinium.*

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3

# PHILOSOPHY IN SPORT

MADE

**SCIENCE IN EARNEST;**

BEING

AN ATTEMPT TO ILLUSTRATE THE FIRST PRINCIPLES
OF NATURAL PHILOSOPHY

BY THE AID OF

POPULAR TOYS AND SPORTS.

By John Ayrton Paris.

A NEW EDITION.

LONDON:
SHERWOOD, GILBERT, & PIPER,
PATERNOSTER ROW.
1833.

Phys 310.1.2

1858. Aug. 22.
Gift of
John J. May, Esq
of Dorchester.

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TO

# MISS MARIA EDGEWORTH.

MADAM,

To whom can a work which professes to blend amusement with instruction, be dedicated with so much propriety, as to one, whose numerous writings have satisfactorily demonstrated the practicability and value of such a union;—to one, who has stripped Romance of her meretricious trappings, and converted her theatre into a temple worthy of Minerva? Justly has it been observed, that to the magic pens of Madame D'Arblay, and yourself, we are indebted for having the Novel restored to its consequence, and, therefore, to its usefulness; and I may be allowed to add, that your Harry and Lucy has shown how profitably, and agreeably, the machinery of fiction may be worked for the dissemination of truth.

That a life which has been so honourable to yourself, and so serviceable to the commonwealth, may be long extended, and deservedly enjoyed, is the fervent wish of

THE AUTHOR.

*London.*

# TO THE READER.

---

Tell me, gentle Reader, whether thou hast not heard of the box of Pandora, which was no sooner opened by the unhappy Epimetheus, than it gave flight to a troop of malevolent spirits, which have ever since tormented the human race.—Behold!—I here present you with a magic casket, containing a genius alone capable of counteracting their direful spells. Thou mayest, perhaps, say that its aspect but ill accords with the richness of its promised treasure; so appeared the copper vessel found by the fisherman, as related in the Arabian tale; but, remember, that no sooner had he broken its mystic seal, than the imprisoned genius spread itself over the ocean and raised its giant limbs above the clouds. But this was an evil and treacherous spirit; mine is as benevolent as he is mighty, and seeks communion with our race for no other object than to render mortals virtuous and happy. His name is Philosophy. To be plain, for you must already, my young friends, have unriddled my allegory, in your progress through life, be not so vain as to believe that you will escape the evils with which its path is beset. Arm yourselves, therefore, with the talisman that can, at once, deprive adversity of its sting, and prosperity of its dangers; for such, believe me, is the rare privilege of philosophy.

I must now take leave of you, for a short time, in order that I may address a few words to your parents and preceptors; but, as I have no plot to abridge your liberties, or lengthen your hours of study, you may listen to my address without alarm, and to my plan without suspicion. Imagine not, however, that I shall recommend the dismissal of the cane, or the whip; on the contrary, I shall insist upon them as necessary and indispensable instruments for the accomplishment of my design. But the method of applying them will be changed; with the one I shall construct the bow of the kite, with the other I shall spin the top.

The object of the present work is to inculcate that early love of science which can never be derived from the sterner productions. Youth is naturally addicted to amusement, and in this item his expenditure too often exceeds his allotted income. I have, therefore, taken the liberty to draw a draft upon Philosophy, with the full assurance that it will be gratefully repaid, with compound interest, ten years after date. But to be serious; those who superintend the education of youth should be apprized of the great importance of the first impressions. Rousseau has said, that the seeds of future vices or virtues are more frequently sown by the mother than the tutor; thereby intimating, that the characters of men are often determined by the earliest impressions; and, of so much moment did Quintillian regard this truth, that he recommends to us the example of Philip, who did not suffer any other than Aristotle to teach Alexander to read. In like manner those who do not commence their study of nature at an early season, will afterwards have many unnecessary obstacles to encounter. The difficulty of comprehending the principles of Natural Philosophy frequently arises from their being at variance with those false ideas which early associations have impressed upon the mind; the first years of study are, therefore, expended in *un*learning, and in clearing away the weeds, which would never have taken root in a properly cultivated soil. Writers on practical education have repeatedly enforced the advantages of the plan I am so anxious to advocate; but, strange to say, it is only within a few years that any works have appeared at all calculated to afford the necessary assistance. In short, previous to the labours of Mrs. Marcet, the productions published for the purpose of juvenile instruction may be justly charged with the grossest errors; and must have proved as destructive to the mind of the young reader, as the book presented by the physician Douban is said to have been to the body of the Grecian king, who, as the Arabian tale relates, imbibed fresh poison as he turned over each leaf, until he fell lifeless in the presence of his courtiers: but these days have happily passed away, and the next generation will illustrate the importance of the reformation.

Allow me, friendly Reader, before I conclude my address, to say a few words upon the plan and execution of the work before you. It is not intended to supersede or clash with any of the elementary treatises to which I have alluded; indeed its plan is so peculiar, that I apprehend such a charge cannot be brought against it. The author originally composed it for the exclusive use of his children, and would certainly never have consigned it to the press, but at the earnest solicitations of those friends upon whose judgment he places the utmost reliance.

It is scarcely necessary to offer any apology for the conversational plan of instruction; the success of Mrs. Marcet's dialogues has placed its value beyond dispute. It may, however, be observed that this species of composition may be executed in two different ways, either as direct conversation, where none but the speakers appear, which is the method used by Plato; or as the recital of a conversation, where the author himself appears, and gives an account of what passed in discourse, which is the plan generally adopted by Cicero. The reader is aware, that Mrs. Marcet, in her "Conversations on Philosophy," has adopted the former, while Miss Edgeworth, in her "Harry and Lucy," has preferred the latter method. In composing the present work I have followed the plan of the last-mentioned authoress. Its advantages over the more direct conversational style appear to consist in allowing occasional remarks, which come more aptly from the author than from any of the characters engaged in the dialogue.

If scientific dialogues are less popular in our times than they were in ancient days, it must be attributed to the frigid and insipid manner in which they have too frequently been executed; if we except the mere external forms of conversation, and that one character is made to speak, and the other to answer, they are altogether the same as if the author himself spoke throughout the whole, instead of amusing with a varied style of conversation, and with a display of consistent and well-supported characters. The introduction of a person of humour, to enliven the discourse, is sanctioned by the highest authority. Cæsar is thus introduced by Cicero, and Cynthio by Addison. In the introduction of Mr. Twaddleton and Major Snapwell, I am well aware of the criticisms to which I am exposed; I have exercised my fancy with a freedom and latitude, for which, probably, there is not any precedent in a scientific work. I have even ventured so far to deviate from the beaten track as to skirmish upon the frontiers of the Novelist, and to bring off captive some of the artillery of romance; but if, by so doing, I have enhanced the interest of my work, and furthered the accomplishment of its object, let me entreat that mere novelty may not be urged to my disparagement. If it be argued that several of my comic representations are calculated, like seasoning, to stimulate the palate of the novel-reader, rather than to nourish the minds of the younger class, for whom the work was written, I may, upon such a charge, at least, plead common usage; for does not the director of a juvenile fête courteously introduce a few piquant dishes, for the entertainment of those elder personages who may attend in the character of a chaperone? You, surely, cannot deny me the full benefit of such a precedent; and so, Gentle Reader, I bid thee—Farewell.

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# PHILOSOPHY IN SPORT.

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THE summer recess of Mr. Pearson's school was not more anxiously anticipated by the scholars than it was by the numerous family of Seymour, who, at the commencement of the year, had parted from a beloved son and brother for the first time. As the season of relaxation approached, so did the inmates of Overton Lodge (for such was the name of Mr. Seymour's seat) betray increasing impatience for its arrival. The three elder sisters, Louisa, Fanny, and Rosa, had been engaged for several days in arranging the little study which their brother Tom had usually occupied. His books were carefully replaced on their shelves, and bunches of roses and jasmines, which the affectionate girls had culled from the finest trees in the garden, were tastefully dispersed through the apartment; the festoons of blue ribbons, with which they were entwined, at once announced themselves as the work of graceful hands, impelled by light hearts; and every flower might be said to reflect from its glowing petals the smiles with which it had been collected and arranged. At length the happy day arrived; a post-chaise drew up to the front gate, and Tom was once again folded in the arms of his affectionate and delighted parents. The little group surrounded their beloved brother, and welcomed his return with all the warmth and artlessness of juvenile sincerity. "Well," said Mr. Seymour, "if the improvement of your mind corresponds with that of your looks, I shall indeed have reason to congratulate myself upon the choice of your school. But have you brought me any letter from Mr. Pearson?" "I have," replied Tom, who presented his father with a note from his master, in which he had commented in high terms of commendation, not only upon Tom's general conduct, but upon the rapid progress which he had made in his classical studies.

"My dearest boy," exclaimed the delighted father, "I am more than repaid for the many anxious moments which I have passed on your account. I find that your conduct has given the highest satisfaction to your master, and that your good-nature, generosity, and, above all, your strict adherence to truth, have ensured the love and esteem of your school-fellows." This gratifying report brought tears of joy into the eyes of Mrs. Seymour; Tom's cheek glowed with the feeling of conscious merit; and the sisters interchanged looks of mutual satisfaction. Can there be an incentive to industry and virtuous conduct so powerful as the exhilarating smiles of approbation which the schoolboy receives from an affectionate parent? Tom would not have exchanged his feelings for all the world, and he internally vowed that he would never deviate from a course that had been productive of so much happiness.

"But come," exclaimed Mr. Seymour, "let us all retire into the library. I am sure that our dear fellow will be glad of some refreshment after his journey."

We shall here leave the family circle to the undisturbed enjoyment of their domestic banquet, and invite the reader to accompany us in a stroll about the grounds of this beautiful and secluded retreat.

We are amongst those who believe that the habits and character of a family may be as easily discovered from the rural taste displayed in the grounds which surround their habitation, as by any examination of the prominences on their heads, or of the lineaments in their faces. How vividly is the decline of an ancient race depicted by the chilling desolation which reigns around the mansion, and by the rank weed which insolently triumphs over its fading splendour; and how equally expressive of the peaceful and contented industry of the thriving cottager, is the well cultivated patch which adjoins the humble dwelling, around whose rustic porch the luxuriant lilac clusters, or the aspiring woodbine twines its green tendrils and sweetly-scented blossoms! In like manner did the elegantly disposed grounds of Overton Lodge at once announce the classic taste and fostering presence of a refined and highly cultivated family.

The house, which was in the Ionic style of architecture, was situated on the declivity of a hill, so that the verdant lawn which was spread before its southern front, after retaining its level for a short distance, gently sloped to the vale beneath, and was terminated by a luxuriant shrubbery, over which the eye commanded a range of fair enclosures, beautified by an irregularly undulating surface, and interspersed with rich masses of wood. The uniformity of the lawn was broken by occasional clumps of flowering shrubs, so artfully selected and arranged, as to afford all the varied charms of contrast; while, here and there, a lofty elm flung its gigantic arms over the sward beneath, and cast a deep shade which enabled the inhabitants of the lodge to enjoy the air, even during the heat of a meridian sun. The shrubbery, which occupied a considerable portion of the valley, stretched for some distance up the western part of the hill; and, could Shenstone have wandered through its winding paths and deep recesses, his favourite Leasowes might have suffered from a comparison. Here were mingled shrubs of every varied dye; the elegant foliage of white and scarlet acacias was blended with the dark-green-leaved chesnut; and the stately branches of the oak were relieved by the gracefully pendulous boughs of the beech. At irregular intervals, the paths expanded into verdant glades, in each of which the bust of some departed poet or philosopher announced the genius to which they were severally consecrated. From a description of one or two of these sequestered spots, the reader will readily conceive the taste displayed in those upon which our limits will not allow us to dwell.

After winding, for some distance, through a path so closely interwoven with shrubs and trees, that scarcely a sunbeam could struggle through the foliage, a gleam of light burst through the gloom, and displayed a beautiful marble figure, which had been executed by a Roman artist, representing Flora in the act of being attired by Spring. It was placed in the centre of the expanse formed by the retiring trees, and at its base were flowering, at measured intervals, a variety of those plants to which Linnæus has given the name of *Equinoctial flowers*, since they open and close at certain and exact hours of the day, and thus by proper arrangement constitute the HOROLOGE OF FLORA. (1)* It had been constructed, under the direction of her mother, by Louisa Seymour. The hour of the day, at which each plant opened, was represented by an appropriate figure of nicely trimmed box; and these, being arranged in a circle, not only fulfilled the duty, but exhibited the appearance of a dial.

From this retreat several winding paths threaded their mazy way through the deep recesses of the wood; and the wanderer, quitting for a while the blaze of day, was refreshed by the subdued light which everywhere pervaded the avenue, except where the hand of taste had, here and there, turned aside the boughs, and opened a vista to bring the village spire into view, or to gladden the sight by a rich prospect of the distant landscape. After having descended for some way, the path, losing its inclined direction, proceeded on a level, and thus announced to the stranger his arrival at the bottom of the valley. What a rich display of woodland scenery was suddenly presented to his view! A rocky glen, in which large masses of sandstone were grouped with picturesque boldness, terminated the path, and formed an area wherein he might gaze on the mighty sylvan amphitheatre, which gradually rose to a towering height above him, and seemed to interpose an insuperable barrier between the solitude of this sequestered spot and the busy haunts of men; not a sound assailed the ear, save the murmur of the summer breeze, as it swept the trembling foliage, or the brawling of a small mountain stream, which gushed from the rock, and, like an angry chit, fretted and fumed as it encountered the obstacles that had been raised by its own impetuosity. This was the favourite retreat of Mr. Seymour, and he had dedicated it to the genius of geology; here had he erected a temple to the memory of Werner, and every pillar and ornament bore testimony to the refined taste of its architect. It consisted of a dome, constructed of innumerable shells and corallines, and surmounted by a marble figure of Atlas, bearing the globe on his shoulders, upon which the name of WERNER was inscribed. The dome was supported by twelve pillars of so singular and beautiful a construction as to merit a particular description; the Corinthian capital of each was of Pentelican marble; the column consisted of a spiral of about six inches in breadth, which wound round a central shaft of not more than two inches in diameter; upon this spiral were placed specimens of various rocks, of such masses as to fill up the outline, and to present to the eye the appearance of a substantial and well-proportioned pillar. These specimens were arranged in an order corresponding with their acknowledged geological relations; thus, the *Diluvial* productions occupied the higher compartments; the *Primitive* strata, the lower ones; and the *Secondary* and *Transition* series found an intermediate place. The tessellated floor presented the different varieties of marble, so artfully interspersed as to afford a most harmonious combination; the *Uni-coloured*, *variegated*, *Madreporic*, the *Lumachella*, *Cipolino*, and *Breccia* marbles, were each represented by a characteristic and well defined specimen. The alcoved ceiling was studded with *Rock Crystal*, calcareous *Stalactites*, and beautiful *Calcedonies*. A group of figures in *basso relievo* adorned the wall which enclosed about a third part of the interior of the temple, and its subject gave evidence of the Wernerian devotion of Mr. Seymour; for it represented a contest between Pluto and Neptune, in which the watery god was seen in the act of wresting the burning torch from the hand of his adversary, in order to quench it in the ocean. Mr. Seymour had studied in the school of Freyburg, under the auspices of its celebrated professor; and, like all the pupils of Werner, he pertinaciously maintained the aqueous origin of our strata. But let us return to the happy party at the Lodge, whom the reader will remember we left at their repast. This having been concluded, and all those various subjects discussed, and questions answered, which the schoolboy, who has ever felt the satisfaction of returning home for the holidays, will more easily conceive than we can describe, Tom enquired of his father, whether his old friend, Mr. Twaddleton, the vicar of Overton, was well, and at the Parsonage. "He is quite well," replied Mr. Seymour, "and so anxious to see you, that he has paid several visits, during the morning, to enquire whether you had arrived. Depend upon it, that many hours will not elapse before you see him."

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* These figures refer to the additional notes at the end of the work.

In that wish did Tom and the whole juvenile party heartily concur; for the vicar, notwithstanding his oddities, was the most affectionate creature in existence, and never was he more truly happy than when contributing to the innocent amusement of his little "*play-mates*," as he used to call Tom and his sisters.

It may be here necessary to present the reader with a short sketch of the character of a person, who will be hereafter found to perform a prominent part in the little drama of Overton Lodge.

The Rev. Peter Twaddleton, Master of Arts, and Fellow of the Society of Antiquaries, for we must introduce him in due form, was about fifty-two years of age, twenty of which he had spent at Cambridge, as a resident Fellow of Jesus College. He had not possessed the vicarage of Overton above eight or nine years; and, although its value never exceeded a hundred and eighty pounds a year, so limited were his wants, and so frugal his habits, that he generally contrived to save a considerable sum out of his income, in order that he might devote it to purposes of charity and benevolence: his charity, however, was not merely of the hand, but of the heart; distress was unknown in his village; he fed the hungry, nursed the sick, and cheered the unfortunate; his long collegiate residence had imparted to his mind several peculiar traits, and a certain stiffness of address and quaintness of manner which at once distinguish the recluse from the man of the world; in short, as Shakspeare expresses it, "*he was not hackneyed in the ways of men.*" His face was certainly the very reverse to every thing that could be considered "good-looking," and yet, when he smiled, there was an animation that redeemed the irregularity of his angular features; so benevolent was the expression of his countenance, that it was impossible not to feel that sentiment of respect and admiration which the presence of a superior person is wont to inspire: but his superiority was rather that of the heart than of the head; not that we would insinuate any deficiency in intellect, but that his moral excellencies were so transcendent as to throw into the shade all those mental qualities which he possessed in common with the world. He entertained a singular aversion to the mathematics, a prejudice which we are inclined to refer to his disappointment in the senate-house; for, although he was known at Cambridge as one of those "pale beings in spectacles and cotton stockings," commonly called "*reading men,*" yet, after all his exertions, he only succeeded in obtaining the "*wooden spoon,*" an honour which devolves upon the last of the "*junior optimes.*" Whether his failure arose from an exuberant or a deficient genius, or, to speak *phrenologically*, from an excess in his *number of bumps*, or a defect in his *bump of numbers*, we are really unable to state, never having had an opportunity of verifying our suspicions by a manual examination of his cranium; he was, however, well read in the classics, and so devoted to the works of Virgil that he never lost an opportunity of quoting his favourite poet; and it must be admitted, that, although these quotations so generally pervaded his conversation as to become irksome, they were sometimes apposite, and now and then even witty. But notwithstanding the delight which he experienced in a *lusus verborum* in a learned language, of such contradictory materials was he composed, that his antipathy to an English pun was extravagant and ridiculous. This peculiarity has been attributed, but we speak merely from common report, to a disgust which he contracted for that species of spurious wit, during his frequent intercourse with the Johnians, a race of students who have, from time immemorial, been identified with the most profligate class of punsters; be this, however, as it may, we are inclined to believe that a person who resides much amongst those who are addicted to this *vice*, unless he quickly takes the infection, acquires a sort of constitutional insusceptibility, like nurses, who pass their lives in infected apartments with perfect safety and impunity. His favourite, and we might add his only pursuit, beyond the circle of his profession, was the study of antiquities; he was, as we have already stated, a Fellow of the Society of Antiquaries; had collected a very tolerable series of ancient coins, and possessed sufficient critical acumen to distinguish between Attic *ærugo*, and the spurious *verdure* of the modern counterfeit. Often had he undertaken an expedition of a hundred miles to inspect the interior of an ancient barrow, or to examine the mouldering fragments of some newly-discovered monument; indeed, like the connoisseur in cheese, blue-mould and decay were the favourite objects of his taste, and the sure passports to his favour; for he despised all *living* testimony, but that of worms and maggots. A coin with the head of a *living* sovereign passed through his hands with as little resistance as water through a sieve, but he grasped the head of an Antonine or Otho with insatiable and relentless avarice. Mr. Twaddleton's figure exceeded the middle stature, and was so extremely slender as to give him the air and appearance of a very tall man. He was usually dressed in an old-fashioned suit of black cloth, consisting of a single-breasted coat, with a standing collar, and deep comprehensive cuffs, and a flapped waistcoat; but so awkwardly did these vestments conform with the contour of his person, that we might have supposed them the production of those Laputan tailors who wrought by mathematical principles, and held in sovereign contempt the illiterate fashioners who deemed it necessary to measure the forms of their customers; although it was whispered by certain censorious persons in the village that the aforesaid mathematical artists were better acquainted with the *angles* of the Seven Dials, than with the *squares* of the west end. They farther surmised that the vicar's annual journey to London, which in truth was undertaken with no other objects than those of attending the anniversary of the Society of Antiquaries, on Saint George's day, and of inspecting the cabinets of his old crony, the celebrated medallist of Tavistock-street, was for the laudable purpose of recruiting his wardrobe. If the aforesaid coat, with its straggling and disproportioned suburbs, possessed an amplitude of dimensions which ill accorded with the slender wants of his person, this misapplied liberality was more than compensated by the rigid economy exhibited in the *nether* part of his costume, which evidently had not been designed by a contemporary artisan; not so his shoes, which, for the accommodation of those unwelcome parasites, vulgarly called *corns*, were constructed in the form of a battledore, and displayed such an unbecoming quantity of leather, that, as Ned Hopkins, a subaltern wit of the village ale-house, observed, "however economical their parson might appear, he was undoubtedly *supported in extravagance*." Nor did the natural association between tithes and "*corn-bags*" escape his observation, but was repeated with various other allusions of equal piquancy, to the no small annoyance of the reverend gentleman, and, as he declared, to the disparagement of his cloth.

After the evening repast had been concluded, Tom proposed a ramble through the shrubbery. He was anxious to revisit the scene of his former sports; and Louisa readily met his wishes, for she was also desirous of showing him the *botanical clock*, which had been planned and completed since his absence. Mr. Seymour accompanied his children, and as they walked across the lawn, Tom asked his father whether he remembered the promise he had made him on quitting home for school, that of furnishing him with some new amusements during the holidays.

"I perfectly remember," said his father, "the promise to which you allude, and I hope that you equally well recollect the conditions with which it was coupled. When your mamma gave you a copy of Mrs. Marcet's instructive Dialogues on Natural Philosophy, I told you that, after you had studied the principles which that work so admirably explains, you would have but little difficulty in understanding the philosophy of toys, or the manner in which each produced its amusing effects; and that, when the midsummer holidays commenced, I would successively supply you with a new amusement, whenever you could satisfactorily explain the principles of those you already possessed. Was not that our contract?"

"It was," exclaimed Tom, with great eagerness, "and I am sure I shall win the prize, whenever you will try me, and I hope my mamma and sisters will be present."

"Certainly," replied Mr. Seymour, "and I trust that Louisa and Fanny, who are of an age to understand the subject, will not prove uninterested spectators. Little John, too, will profit by our scheme; for, as I shall necessarily require, for illustration, certain toys which can scarcely afford any amusement to a boy of your age and acquirements, it is but fair that they should be transferred into his hands."

"Thank you! thank you! dear papa," was simultaneously shouted by several voices, and the happy children looked forward to the morrow, with that mixed sensation of impatience and delight which always attends juvenile anticipations.

At this critical moment, the vicar was seen approaching, and Tom and his sisters immediately ran forward to greet him.

"My dear boy," exclaimed the vicar, "I am truly rejoiced to see you;—when did you arrive from school?—How goes on Virgil?—Hey, my boy?—You must be delighted with the great Mantuan bard;—now confess, you little Trojan, can you eat a cheesecake without being reminded of the Harpy's prophecy, and its fulfilment, as discovered by young Ascanius:—

> Heus! etiam *mensas* consumimus, inquit Iulus.
>
> ÆN. vii. 116.

"But, bless me, how amazingly you have grown! and how healthy you look!" . Tom took advantage of this pause in the vicar's address, which had hitherto flowed in so uninterrupted and rapid a stream as to preclude the possibility of any reply to his questions, to inform him that his father was on the lawn, and desirous of seeing him.

"Mr. Twaddleton," exclaimed Mr. Seymour, "you are just in time to witness the commencement of a series of amusements, which I have proposed for Tom's instruction during the holidays."

"Amusement and instruction," replied the vicar, "are not synonymous in my vocabulary; unless, indeed, they be applied to the glorious works of Virgil; but let me hear your scheme."

"I have long thought," said Mr. Seymour, "that all the first principles of natural philosophy might be easily taught, and beautifully illustrated, by the common toys which have been invented for the amusement of youth."

"A fig for your philosophy," was the unceremonious and chilling reply of the vicar. "What have boys," continued he, "to do with philosophy? Let them learn their grammar, scan their hexameters, and construe Virgil; it is time enough to inflict upon them the torments of science after their names have been entered on the University boards."

"I differ from you entirely, my worthy friend; the principles of natural philosophy cannot be too early inculcated, nor can they be too widely diffused. It is surely a great object to engage the prepossessions on the side of truth, and to direct the natural curiosity of youth to useful objects."

"Hoity toity!" exclaimed the reverend gentleman, "such principles accord not with my creed; heresy, downright heresy; that a man of your excellent sense and intelligence can be so far deceived! But the world has run mad, and much do

I grieve to find, that the seclusion of Overton Lodge has not secured its inmates from the infection. I came here, Mr. Seymour, to receive your sympathy, and to profit by your counsel, but, alas! alas! I have fallen into the camp of the enemy. '*Medios delapsus in hostes,*' as Virgil has it."

"You astonish me,—what can have happened?" asked Mr. Seymour.

"There is Tom Plank, the carpenter," said the vicar, "soliciting subscriptions for the establishment of a philosophical society. I understand that this mania—for by what other, or more charitable term can I express such conduct?—has seized this deluded man since his return from London, where he has been informed that all the "hewers of wood and drawers of water" are about to associate themselves into societies for the promotion of science. Preposterous idea! as if a block of wood could not be split without a knowledge of the doctrine of percussion, nor a pail of water drawn from the well, without an acquaintance with hydrostatics; but, as I am a Christian priest, I solemnly declare, that I grieve only for my flock, and raise my feeble voice for no other purpose than that of scaring the wolf from the fold: to be angry, as Pope says, would be to revenge the faults of others upon ourselves; but I am not angry, Mr. Seymour, I am vexed, sorely vexed."

"Take it not thus to heart, my dear vicar," replied his consoling friend; "'*Solve metus,*' as your poet has it. Science, I admit, is both the Pallas and Pandora of mankind; its abuse may certainly prove mischievous, but its sober and well-timed application cannot fail to increase the happiness of every class of mankind, as well as to advance and improve every branch of the mechanical arts; so thoroughly am I satisfied upon this point, that I shall subscribe to the proposed society with infinite satisfaction."

"Mr. Seymour! Mr. Seymour! you know not what you do. Would you scatter the seeds of insubordination? manure the weeds of infidelity? fabricate a battering-ram to demolish our holy church? Such, indeed, must be the effect of your Utopian scheme, for truly may I exclaim with the immortal Maro—

> In nostros fabricata est machina muros." *

"Come, come, my good friend, all this is declamation without argument."

"Without argument! Many are the sad instances which I could adduce in proof of the evil effects which have already accrued from this abominable system. I am not in the habit, Sir, of dealing in empty assertion; already has the aforesaid Tom Plank ventured to question the classical knowledge of his spiritual pastor, and, as I understand, has openly avowed himself, at the sixpenny club, as my rival in antiquarian pursuits."

"And why should he not?" said the mischievous Mr. Seymour; "I warrant you he already possesses many an *old saw;* ay, and of a very great age too, if we may judge from the *loss of its teeth.*"

During this remonstrance, Mr. Twaddleton had been occupied in whirling round his steel watch-chain with inconceivable rapidity, and, after a short pause, he burst out into the following exclamation:—

"Worthy Sir! if you persist in asserting, that a man whose occupation is to *plane deal,* is prepared to dive into the sacred mysteries of antiquity, I shall next expect to hear that"—

"A truce, a truce," cried Mr. Seymour, interrupting the vicar, "to all such hackneyed objections; and let us *deal plainly* with your *planer* of *deals:* you assert that the carpenter cannot speak grammatically, and yet he gains his livelihood by *mending stiles;* you complain of his presumption in argument, would it not be a desertion of his *post* to decline *railing?* and then, again, with respect to his antiquarian pretensions, compare them with your own; *you* rescue *saws from the dust, he* obtains *dust* from his *saws.*"

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* "An engine's raised to batter down our walls."
ÆN. ii. 46.

"What madness has seized my unfortunate friend?

Infelix! quæ tanta animum dementia cepit?

as Virgil has it:—But let it pass, let it pass, Mr. Seymour; my profession has taught me to bear with humility and patience the contempt and revilings of my brethren; I forgive Tom Plank for his presumption, as in that case I alone am the sufferer; but I say to you, that envy, trouble, discontent, strife, and poverty will be the fruits of the seeds you would scatter. I verily believe, that unless this 'march of intellect,' as it has been termed, is speedily checked, Overton, in less than twelve months, will become a deserted village; for there is scarcely a tradesman who is not already distracted by some visionary scheme of scientific improvement, that leads to the neglect of their occupations, and the dissipation of the honest earnings which their more prudent fathers had accumulated; '*Meliora pii docuere parentes,*' as the poet has it. What think you of Sam Corkington, who proposes to erect an apparatus in the crater of Mount Vesuvius, in order to supply every city on the continent with heat and light; or of Billy Spooner, who is about to establish a dairy at Spitzbergen, in order that he may furnish all Europe with ice-cream from the milk of whales!

The vicar was about to proceed with his lamentations, but the thread of his discourse was suddenly snapped asunder, and his ideas thrown into the wildest confusion, by the explosion of a most audacious pun, which in mercy to Mr. Seymour, as well as to our readers, we will not repeat.

"Mr. Seymour," exclaimed the incensed vicar, "we will, if you please, terminate our discourse; I perceive that you are determined to meet my remonstrances with ridicule; when I had hoped to bring an argument incapable of refutation, *Tum variæ illudunt pestes*, as Virgil has it."

"Pray, allow me to ask," said Mr. Seymour, "whether my puns, or your quotations, best merit the title of *pestes?*"

"That you should compare the vile practice of punning with the elegant and refined habit of conveying our ideas by classic symbols, does indeed surprise and disturb me. Pope has said that words are the counters by which men represent their thoughts; the plebeian," continued the vicar, "selects base metal for their construction, while the scholar forms them of gold and gems, dug from the richest mines of antiquity. But to what vile purpose does the punster prostitute such counters? Not for the interchange of ideas, but, like the juggler, to deceive and astonish by acts of legerdemain."

"How fortunate is it that you had not lived in the reign of King James," continued Mr. Seymour; "for that singular monarch, as you may, perhaps, remember, made very few bishops who had not thus signalised themselves."

"To poison our ears by quibbles and quirks did well become him who sought to deceive our senses and blind our reason—the patron of puns and the believer in witchcraft were suitably united," remarked the vicar.

"Well," said Mr. Seymour, "as this is a subject upon which it is not likely that we should agree, I will pass to another, where I hope to be more successful; I trust I shall induce you to view with more complacency my project of teaching philosophy by the aid of toys and sports."

"Mr. Seymour, the proposal of instructing children in the principles of natural philosophy, is really too visionary to require calm discussion; and can be equalled only in absurdity by the method you propose for carrying it into effect."

"Indulge me, nevertheless, so far as to listen to the plan," said Mr. Seymour, "by which it is my intention to turn sport into science, or, in other words, toys into instruments of philosophical instruction."

"And is it then possible," said the vicar, in a tone of supplication, "that you can seriously entertain so wild, and, I might even add, so cruel a scheme? Would you pursue the luckless little urchin from the schoolroom into the very playground, with your unrelenting tyranny? a sanctuary which the most rigid pedagogue has hitherto held inviolable. Is the buoyant spirit so forcibly, though perhaps necessarily, repressed, during the hours of discipline, to have no interval for its free and uncontrolled expansion? Your science, methinks, Mr. Seymour, might have taught you a wiser lesson; for you must well know that the most elastic body will lose its resilient property if it be constantly kept in a state of tension."

"A fine specimen of sophistry, upon my word," cried Mr. Seymour, "which would, doubtless, raise every nursery-governess and doating grandmother in open rebellion against me; but let me add, that it ill becomes a man of liberal and enlarged ideas, to suffer his opinions to be the sport of mere words; for, that our present difference is an affair of words, and of words only, I will undertake to prove, to the satisfaction of any unprejudiced person. *Play* and *work*—*amusement* and *instruction*—*toys* and *tasks*—are invariably but most unjustifiably employed as words of contrast and opposition; an error which has arisen from the indistinct and very indefinite ideas which we attach to such words. If the degree of mental exertion be said to constitute the difference between *play* and *work*, I am quite sure that the definition would be violated in the first illustration; for let me ask, when do boys exert so much thought as in carrying into effect their holiday schemes? The distinction may, perhaps, be made to turn upon the irksome feelings which might be supposed to attend the drudgery of study, but this can never happen except from a vicious system of education that excludes the operations of thought; a school that locks in the body, but locks out the mind: depend upon it, Mr. Twaddleton, that the human mind, whether in youth or manhood, is ever gratified by the acquisition of information; every occupation soon cloys, unless it be seasoned by this stimulant. Is not the child idle and miserable in a nursery full of playthings, and to what expedient does he instinctively fly to relieve his *ennui*? Why, he breaks his toys to pieces, as Miss Edgeworth justly observes, not from the love of mischief, but from the hatred of idleness, or rather from an innate thirst after knowledge; and he becomes, as it were, an enterprising adventurer, and opens for himself a new source of pleasure and amusement, in exploring the mechanism of their several parts. Think you, then, Mr. Twaddleton, that any assistance which might be offered the boy, under such circumstances, would be received by him as a task? Certainly not. The acquisition of knowledge then, instead of detracting from, must heighten the amusement of toys; and, if I have succeeded in convincing you of this truth, my object is accomplished."

Thus did Mr. Seymour, like an able general, assail his adversary on his own ground; he drove him, as it were, into a corner, and by seizing the only pass through which he could make his escape, forced him to surrender at discretion.

"Why, truly," replied the vicar, after a short pause, "I am ready to admit that there is much good sense in your observations; and, if the scientific instruction upon these occasions be not carried so far as to puzzle the boy, I am inclined to coincide with you."

"Therein lies the whole secret," said Mr. Seymour: "when an occupation agreeably interests the understanding, imagination, or passions of children, it is what is commonly understood by the term *play* or *sport;* whereas that which is not accompanied with such associations, and yet may be necessary for their future welfare, is, properly enough, designated as a *task.*"

"I like the distinction," observed the vicar.

"Then may I hope that you will indulge me so far as to listen to the scheme, by which it is my intention to turn 'Sport into Science,' or, in other words, *Toys* into instruments of *Philosophical Instruction?*"

The vicar nodded assent.

Mr. Seymour proceeded—"In the first place, I would give the boy some general notions with regard to the properties of matter, such as its gravitation, vis inertiæ, elasticity, &c. What apparatus can be required for such a purpose, beyond some of the more simple toys? Indeed, I will undertake to demonstrate the three grand laws of motion by a game at ball; while the composition and resolution of forces may be beautifully exemplified during a game of marbles, especially that of "ring-taw:" but in order that you may more clearly comprehend the capability of my plan, allow me to enumerate the various philosophical principles which are involved in the operation of the several more popular toys and sports. We will commence with the ball; which will illustrate the nature and phenomena of *elasticity*, as it leaps from the ground;—of *rotatory motion*, while it runs along its surface;—of *reflected motion*, and of the *angles of incidence and reflection*, as it rebounds from the wall;—and of *projectiles*, as it is whirled through the air: at the same time the cricket-bat may serve to explain the *centre of percussion*. A game at marbles may be made subservient to the same purposes, and will farther assist us in conveying clear ideas upon the subject of the *collision of elastic and non-elastic bodies*, and of their *velocities and direction after impact*. *The composition and resolution of forces* may be explained at the same time. The nature of *elastic springs* will require no other apparatus for its elucidation than Jack in the box, and the numerous leaping-frogs and cats with which the nursery abounds. The leathern sucker will exemplify the nature of *cohesion*, and the effect of water in filling up those inequalities by which contiguous surfaces are deprived of their attractive power; it will, at the same time, demonstrate the nature of a *vacuum*, and the influence of *atmospheric pressure*. The squirt will afford a farther illustration of the same views, and will furnish a practical proof of the weight of the atmosphere in raising a column of water. The theory of the pump will necessarily follow. The various balancing toys will elucidate the nature of the *centre of gravity*, *point of suspension*, and *line of direction*: the see-saw, rocking-horse, and the operation of walking on stilts, will here come in aid of our explanations. The combined effects of momentum and a change in the centre of gravity of a body may be beautifully exemplified by the action of the Chinese Tumblers. The sling will demonstrate the existence and effect of *centrifugal force;* the top and tetotum will prove the power of vertiginous motion to support the axis of a body in an upright position. The trundling of the hoop will accomplish the same and other objects. The game of *bilboquet,* or cup and ball, will show the influence of rotatory motion in steadying the rectilinear path of a spherical body, whence the theory of the rifle gun may be deduced. For conveying some elementary ideas of the doctrine of *oscillation,* there is the swing. The flight of the arrow will not only elucidate the principles of *projectiles,* but will explain the force of the air in producing rotatory motion by its impact on oblique surfaces: the revolution of the shuttlecock may be shown to depend upon the same resolution of forces. Then comes the kite, one of the most instructive and amusing of all the pastimes of youth,—the favourite toy of Newton in his boyish days:*—its ascent at once developes the theory of the composition and resolution of forces, and explains various subordinate principles, which I shall endeavour to describe when we arrive at the subject. The *see-saw* will unfold the general principle upon which the Mechanical Powers are founded; and the boy may thus be easily led to the theory of the *lever*, by being shown how readily he can balance the heavier weight of a man by riding on the longer arm of the plank. The theory of colours may be pointed out to him as he blows his soap-bubbles;* an amusement which will, at the same time, convince him that the air must exert a pressure equally in all directions. For explaining the theory of sound, there are the whistle, the humming-top, the whizgig, the pog-gun, the bull-roarer, and sundry other amusements well known in the play-ground; but it is not my intention, at present, to enumerate *all* the toys which may be rendered capable of affording philosophical instruction; I merely wish to convince you that my plan is not quite so chimerical as you were at first inclined to believe."

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* Sir Isaac Newton is said to have been much attached to Philosophical sports when a boy; he was the first to introduce paper kites at Grantham, where he was at school. He took pains to find out their proper proportions and figure, and the proper place for fixing the string to them. He made lanterns of paper crimpled, which he used to go to school by in winter mornings with a candle, and he tied them to the tail of his kites in a dark night, which at first frightened the country people exceedingly, who took his candles for comets.—*Thomson's Hist. of R. S.*

"Upon my word," said the vicar, "no squirrel ever hopped from branch to branch with more agility,—you are the very counterpart of Cornelius Scriblerus; but I must confess that your scheme is plausible, very plausible, and I shall no longer refuse to attend you in the progress of its execution.

> Cedo equidem, nec nate, tibi comes ire recuso, †

as Virgil has it."

Mr. Seymour, however, saw very plainly that, although the vicar thus withdrew his opposition, he was nevertheless very far from embarking in the cause with enthusiasm, and that, upon the principle already discussed, he would perform his part rather as a *task* than a *pastime*. Nor was the line which Mr. Twaddleton had quoted from the

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* The colours which glitter on a soap-bubble are the immediate consequence of a principle the most important from the variety of phenomena it explains, and the most beautiful from its simplicity and compendious neatness in the whole science of Optics.—*Herschel's Preliminary Discourses.*

† "I yield, my son, and no longer refuse to become your companion."—ÆN. ii. 704.

Æneid calculated to efface such an impression. It was true, that, like Anchises, he no longer refused to accompany him in his expedition; but, if the comparison were to run parallel, it was evident that he would have to carry him as a dead weight on his shoulders. This difficulty, however, was speedily surmounted by an expedient, with which the reader will become acquainted by the recital of what followed.

"I rejoice greatly," said Mr. Seymour, "that we have at length succeeded in enlisting you into our service; without your able assistance, I fear that my instruction would be extremely imperfect; for you must know, my dear Sir, that I am ambitious of making Tom an antiquary as well as a philosopher, and I look to you for a history of the several toys which I shall have occasion to introduce."

This propitiatory sentence had its desired effect.

"Most cheerfully shall I comply with your wishes," exclaimed the delighted vicar; "and I can assure you, Sir, that, with regard to several of the more popular toys and pastimes, there is much very curious and interesting lore."

Mr. Seymour had upon this occasion succeeded in opening the heart of the vicar, just as a skilful mechanic would pick a patent lock; who, instead of forcing it by direct violence, seeks to discover the secret spring to which all its various movements are subservient.

"To-morrow, then," cried the vicar, in a voice of great exultation, "we will commence our career, from which I anticipate the highest satisfaction and advantage; in the mean time," continued he, "I will refresh my memory upon certain points touching the antiquities of these said pastimes, or, as we used to say at college, *get up* the subject. I will also press into our service my friend and neighbour Jeremy Prybabel, whose etymological knowledge will greatly assist us in tracing the origin of many of the words used in our sports, which is frequently not very obvious."

Mr. Seymour cast an intelligible glance at his wife, who was no less surprised at the sudden change in the vicar's sentiments than she was pleased with the skill and address by which it had been accomplished.

"To-morrow!" said Tom.

"To-morrow!!" echoed Fanny.

"To-morrow, and to-morrow, and to-morrow!" sighed Louisa; "why not to-day? for it is not yet one o'clock."

"Be it so," replied her father, "and I hope that Mr. Twaddleton will afterwards join our family circle at dinner."

The vicar accepted the invitation, but observed that his parochial duties obliged him to absent himself for an hour, after which he faithfully promised to return. The good-humoured clergyman then shook Tom by the hand, and departed in company with Mr. Seymour, while the juvenile party were left to their amusements in the garden.

# CHAPTER II.

ON GRAVITATION.—WEIGHT.—THE VELOCITY OF FALLING BODIES.—AT WHAT ALTITUDE A BODY WOULD LOSE ITS GRAVITY.—THE TOWER OF BABEL.—THE KNOWN VELOCITY OF SOUND AFFORDS THE MEANS OF CALCULATING DISTANCES.—AN EXCURSION TO OVERTON WELL.—AN EXPERIMENT TO ASCERTAIN ITS DEPTH.—A VISIT TO THE VICARAGE.—THE MAGIC GALLERY.—RETURN TO THE LODGE.

It was about two o'clock, when Mr. Twaddleton, in company with Mr. and Mrs. Seymour, joined the children on the lawn.

"Tom," said his father, "are you prepared to commence the proposed examination?"

"Quite ready, papa."

"Then you must first inform me," said Mr. Seymour, taking the ball out of Rosa's hand, "why this ball falls to the ground, as soon as I withdraw from it the support of my hand?"

"Because every *heavy* body, that is not supported, must of course fall."

"And every *light* one also, my dear; but that is no answer to my question; you merely assert the fact, without explaining the reason."

"Oh! now I understand you; it is owing to the force of gravity; the earth attracts the ball, and the consequence is, that they both come in contact;—is not that right?"

"Certainly; but if the earth attract the ball, it is equally true that the ball must attract the earth; for you have, doubtless, learnt that bodies mutually attract each other: tell me, therefore, why the earth should not rise to meet the ball?"

"Because the earth is so much larger and heavier than the ball."

"It is, doubtless, much larger, and since the force of attraction is in proportion to the mass, or quantity of matter, you cannot be surprised at not perceiving the earth rise to meet the ball, the attraction of the latter being so infinitely small, in comparison with that of the former, as to render its effect wholly nugatory; but with regard to the earth being heavier than the ball, what will you say when I tell you that it has no weight at all?"

"No weight at all!"

Tom begged that his father would explain to him how it could possibly be that the earth should not possess any weight.

"Weight, my dear boy, you will readily understand, can be nothing more than an effect arising out of the resisted attraction of a body for the earth: you have just stated, that all bodies have a tendency to fall, in consequence of the attraction of gravitation; but if they be supported, and prevented from approaching the earth, either by the hand, or any other appropriate means, their tendency will be felt, and is called *weight.*"

Tom understood this explanation, and observed, that "since attraction was always in proportion to the quantity of matter, so, of course, a larger body must be more powerfully attracted, or be *heavier,* than a smaller one."

"Magnitude, or size, my dear, has nothing whatever to do with quantity of matter: will not a small piece of lead weigh more than a large piece of sponge? In the one case, the particles of matter may be supposed to be packed in a smaller compass; in the other, there must exist a greater number of pores or interstices."

"I understand all you have said," observed Louisa, "and yet I am unable to comprehend why the earth cannot be said to have any weight."

"Cannot you discover," answered Mr. Seymour, "that, since the earth has nothing to attract it, it cannot have any attraction to resist, and, consequently, according to the ordinary acceptation of the term, it cannot be correctly said to possess weight? although I confess that, when viewed in relation to the solar system, a question will arise upon this subject, since it is attracted by the sun.

The children declared themselves satisfied with this explanation, and Mr. Seymour proceeded to put another question: "Since," continued he, "you now understand the nature of that force by which bodies fall to the earth, can you tell me the degree of velocity with which they fall?"

Tom asserted, that the weight of the body, or its quantity of matter, and its distance from the surface of the earth, must, in every case, determine that circumstance; but Mr. Seymour excited his surprise by saying, that it would not be influenced by either of those conditions; he informed them, for instance, that a cannon-ball, and a marble, would fall through the same number of feet in a given time, and that, whether the experiment were tried from the top of a house, or from the summit of Saint Paul's, the same result would be obtained.

"I am quite sure," exclaimed Tom, "that, in the *Conversations on Natural Philosophy*, it is positively stated, that *attraction is always in proportion to the quantity of matter*."

"Yes," observed Louisa, "and it is moreover asserted, that the *attraction diminishes as the distances increase*."

Mr. Seymour said, that he perceived the error under which his children laboured, and that he would endeavour to remove it. "You cannot, my dears," continued he, "divest your minds of that erroneous but natural feeling, that a body necessarily falls to the ground without the exertion of any force; whereas the greater the quantity of matter, the greater must be the force exerted to bring it to the earth: for instance, a substance which weighs a hundred pounds will thus require just ten times more force than one which only weighs ten pounds; and hence it must follow, that both will come to the ground at the same moment; for, although, in the one case, there is ten times more matter, there is, at the same time, ten times more attraction to overcome its resistance; for you have already admitted that the force of attraction is always in proportion to the quantity of matter. Now let us only for an instant, for the sake merely of argument, suppose that attraction had been a force acting without any regard to quantity of matter, is it not evident that, in such a case, the body containing the largest quantity would be the slowest in falling to the earth?"

"I understand you, papa," cried Tom: "if an empty waggon travelled four miles an hour, and were afterwards so loaded as to have its weight doubled, it could only travel at the rate of two miles in the same period, provided that in both cases the horses exerted the same strength."

"Exactly," said Mr. Seymour; "and to follow up your illustration, it is only necessary to state, that Nature, like a considerate master, always apportions the number of horses to the burthen that is to be moved, so that her loads, whatever may be their weight, always travel at the same rate; or, to express the fact in philosophical instead of figurative language, gravitation, or the force of the earth's attraction, always increases as the quantity of matter, and, consequently, that heavy and light bodies, when dropped together from the same altitude, must come to the ground at the same instant of time."

Louisa had listened with great attention to this explanation; and although she thoroughly understood the argument, yet it appeared to her at variance with so many facts with which she was acquainted, that she could not give implicit credence to it.

"I think, papa," said the archly-smiling girl, "I could overturn this fine argument by a very simple experiment."

"Indeed! Miss Sceptic: then pray proceed; and I think we shall find that the more strenuously you oppose it, the more powerful it will become: but let us hear your objections."

"I shall only," replied she, "drop a shilling, and a piece of paper, from my bed-room window upon the lawn, and request that you will observe which of them reaches the ground first; if I am not much mistaken, you will find that the coin will strike the earth before the paper has performed half its journey."

Tom appeared perplexed, and cast an enquiring look at his father.

"Come," said Mr. Seymour, "I will perform this experiment myself, and endeavour to satisfy the doubts of our young sceptic; but I must first take the opportunity to observe, that I am never better pleased than when you attempt to raise difficulties in my way, and I hope you will always express them without reserve."

"Here, then, is a penny piece; and here," said Tom, "is a piece of paper."

"Which," continued Mr. Seymour, "we will cut into a corresponding shape and size." This having been accomplished, he held the coin in one hand, and the paper disc in the other, and dropped them at the same instant.

"There! there!" cried Louisa, with an air of triumph; "the coin reached the ground long before the paper."

"I allow," said Mr. Seymour, "that there was a distinct interval in favour of the penny piece;" and he proceeded to explain the cause of it. He stated that the result was not contrary to the law of gravitation, since it arose from the interference of a foreign body, the air, to the resistance of which it was to be attributed; and he desired them to consider the particles of a falling body as being under the influence of two opposing forces,—gravity, and the air's resistance. Louisa argued, that the air could only act on the surface of a body, and as this was equal in both cases (the size of the paper being exactly the same as that of the penny piece,) she could not see why the resistance of the air should not also be equal in both cases.

"I admit," said Mr. Seymour, "that the air can only act upon the surface of a falling body, and this is the very reason of the paper meeting with more resistance than the coin; for the latter, from its greater density, must contain many more particles than the paper, and upon which the air cannot possibly exert any action; whereas almost every particle of the paper may be said to be exposed to its resistance, the fall of the latter must therefore be more retarded than that of the former body."

At this explanation Louisa's doubts began to clear off, and they were ultimately dispelled on Mr. Seymour performing a modification of the above experiment in the following manner. He placed the disc of paper in close contact with the upper part of the coin, and, in this position, dropped them from his hand. They both reached the ground at the same instant.

"Are you now satisfied, my dear Louisa?" asked her father: "you perceive that, by placing the paper in contact with the coin, I skreened it from the action of the air, and the result is surely conclusive."

"Many thanks to you, dear papa; I am perfectly satisfied, and shall feel less confident for the future." Tom was delighted; for, as he said, he could now understand why John's paper *parachute* descended so deliberately to the ground; he could also explain why feathers, and other light bodies, floated in the air. "Well then," said Mr. Seymour, "having settled this knotty point, let us proceed to the other question, viz. 'that a body will fall with the same velocity, during a given number of feet, from the ball of St. Paul's as from the top of a house.' You maintain, I believe, that, since the attraction of the earth for a body diminishes as its distance from it increases,* a substance at a great height ought to fall more slowly than one which is dropped from a less altitude."

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* Gravity, or the tendency of a body to approach the earth, is

Neither Tom nor Louisa could think otherwise. Mr. Seymour told them that, *in theory*, they were perfectly correct, but that, since attraction acted from the centre, and not from the surface of the earth, the difference of its force could not be discovered at the small elevations to which they could have access: "For what," said he, "can a few hundred feet be in comparison with four thousand miles, which is the distance from the centre to the surface of our globe?—You must therefore perceive that, in all ordinary calculations respecting the velocity of falling bodies, we may safely exclude such a consideration."

"But suppose," said Tom, "it were possible to make the experiment a thousand miles above the earth, would not the diminished effect of gravity be discovered in that case?"

"Undoubtedly," replied his father; "indeed, it would be sensible at a much less distance: for instance, if a lump of lead, weighing a thousand pounds, were carried up only four miles, it would be found to have lost two pounds of its weight." (2)

"This discussion," observed Mr. Twaddleton, "reminds me of a problem that was once proposed at Cambridge, to find the elevation to which the Tower of Babel could have been raised, before the stones would have entirely lost their gravity."

"Its solution," said Mr. Seymour, "would require a consideration which Tom could not possibly

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proportioned to the *square of the distance*; that is, if a body be attracted by the earth at a certain distance, with a certain force, and be afterwards removed to *twice* the distance, it will now be attracted, not *half* as much, but only *one-fourth* as much as it was before; and if it be removed to *three* times the first distance, it will be attracted not *one-third* as much, but one *one-ninth*, as much as before; four being the square of two, and nine the square of three.

understand at present, viz. the influence of the *centrifugal force*."

"I am fully aware of it," replied the vicar, "and in order to appreciate that influence, it would, of course, be necessary to take into account the latitude of the place; but, if my memory serves me, I think that, under the latitude of 30°, which I believe is nearly that of the plains of Mesopotamia, the height would be somewhere about twenty-four thousand miles."

Mr. Seymour now desired Tom to inform him, since all bodies fall with the *same* velocity, what that velocity might be.

"Sixteen feet in a second, papa;—I have just remembered that I had a dispute with a school-fellow upon that subject, and in which, thanks to Mrs. Marcet, I came off victorious, and won twelve marbles."

"Then let me tell you, my fine fellow, that unless your answer exclusively related to the *first* second of time, you did not win the marbles fairly; for, since the force of gravity is continually acting, so is the velocity of a falling body continually increasing, or it has what is termed an '*accelerating velocity;*' it has accordingly been ascertained by accurate experiments, that a body descending from a considerable height falls sixteen feet, as you say, in the *first* second of time; but *three times sixteen* in the next; *five times sixteen* in the third; and *seven times sixteen* in the fourth; and so on, continually increasing according to the odd numbers 1, 3, 5, 7, 9, 11, &c. so that you perceive," continued Mr. Seymour, "by observing the number of seconds which a stone requires to descend from any height, we can discover the altitude, or depth, of the place in question."

Louisa and Fanny, who had been attentively listening to their father's explanation, interchanged a smile of satisfaction, and, pulling Tom towards them, whispered something which was inaudible to the rest of the party.

"Come, now," exclaimed Mr. Seymour, "I perceive by your looks that you have something to ask of me: is Louisa sceptical again?"

"Oh dear no," replied Tom; "Louisa merely observed, that we might now be able to find out the depth of the village well, about which we have all been very curious; for the gardener has told us that it is the deepest in the kingdom, and was dug more than a hundred years ago."

Mr. Seymour did not believe that it was the deepest in the kingdom, although he knew that its depth was considerable; and he said that, if Mr. Twaddleton had no objection, they should walk to it, and make the proposed experiment.

"Objection! my dear Mr. Seymour, when do I ever object to afford pleasure to my little playmates, provided its indulgence be harmless? Let us proceed at once, and on our return I hope you will favour me with a visit at the vicarage; I have some antiquities which I am anxious to exhibit to yourself and Mrs. Seymour." Tom and Rosa each took the vicar's hand, and Mr. and Mrs. Seymour followed with Louisa and Fanny. The village well was about half a mile distant; the road to it led through a delightful shady lane, at the top of which stood the vicarage-house. Mr. and Mrs. Seymour and her daughters had lingered in their way to collect botanical specimens, and when they had come up to Tom and the vicar, they found them seated on the trunk of a newly-felled oak, in deep discourse.

"What interests you, Tom?" said Mr. Seymour, who perceived, by the enquiring and animated countenance of the boy, that his attention had been excited by some occurrence.

"I have been watching the woodman," said Tom, "and have been surprised that the sound of his hatchet was not heard until some time after he had struck the tree."

"And has not Mr. Twaddleton explained to you the reason of it?" asked Mr. Seymour.

"He has," replied Tom, "and he tells me that it is owing to sound travelling so much more slowly than light."

"You are quite right, and as we are upon an expedition for the purpose of measuring depths, it may not be amiss to inform you, that this fact furnishes another method of calculating distances."

The party seated themselves upon the oak, and Mr. Seymour proceeded: "The stroke of the axe is seen at the moment the woodman makes it, on account of the immense velocity with which light travels; (3) but the noise of the blow will not reach the ear until some time has elapsed, the period varying, of course, in proportion to the distance, because sound moves only at the rate of 1142 feet in a second, or about 13 miles in a minute; so that you perceive, by observing the time that elapses between the fall of the hatchet and the sound produced by it, we can ascertain the distance of the object."

Mr. Seymour fixed his eye attentively on the woodman, and, after a short pause, declared that he was about half a quarter of a mile distant.

"Why, how could you discover that?" cried Louisa; "you had not any watch in your hand."

"But," said Mr. Seymour, "you might have perceived that I placed my finger on my wrist, and as my pulse beat about 75 strokes in a minute, I was able to form a tolerable estimate of the interval, although I confess that it is a very rough experiment, but sufficiently accurate for the purpose of illustration. In the same manner we can readily ascertain the distance of a thundercloud, or that of a vessel at sea firing a cannon. If we do not hear the thunder till half a minute after we see the lightning, we are to conclude the cloud to be at the distance of six miles and a half. But let us proceed to the well."

After a walk of a few minutes, the party reached the place of destination. On their arrival, Mr. Seymour enquired who would count the time.

"Be that office mine," said Mr. Twaddleton, as he extracted a large silver time-piece from the dark abyss of his watch-pocket; "and let Tom," continued he, "find a pebble."

"Here is one," cried Louisa.

"Very well: now, then, how will you proceed?" asked Mr. Seymour.

"I shall drop the stone," replied Tom, "into the well, and observe how many seconds it will be before it touches the water, and I shall then set down the number of feet it will fall in each second, and add up the numbers."

"That," said Mr. Seymour, "would certainly accomplish your object; but I can give you a neater, as well as a shorter rule for performing the sum: you shall, however, first work it in your own way;—but you have not yet informed me how you propose to ascertain the moment at which the stone reaches the water."

"By the sound, to be sure, papa; and you will find that a very loud one will be produced."

"If the depth of the well be considerable, such a plan will not answer the purpose, since, in that case, there must necessarily be a perceptible interval between the fall of the stone and the sound produced by it, as you have just seen exemplified by the woodman, which, unless taken into account, (4) will vitiate the result."

Tom observed that he had not thought of that difficulty, and did not know how he could get over it. His father told him, that he must look at the surface of the water, and mark the moment it was disturbed by the stone.

"Now, Mr. Twaddleton," exclaimed Mr. Seymour, "are you ready to count the seconds?"

"Quite ready."

"Then drop the stone."

"One,—two,—three,—four—

"There," said Tom, "it touched the water."

"And there, there," cried several voices, "what a noise it made!"

"*Facilis descensus Averni*," exclaimed the vicar; "the stone descended in four seconds."

"Now, my boy, make your calculation."

Mr. Seymour furnished pencil and paper, and Tom proceeded;—"*Sixteen* feet for the first second,—I put that down."—

"Well," said his father, "and *three* times *sixteen* for the second?"

"*Forty-eight*," cried Tom.—

"Put it down."

"*Five times sixteen*, for the third?"

"*Eighty*."—

"Down with it."

"And *seven times sixteen*, for the fourth?"

"*One hundred and twelve*."

"Now, cast up these numbers," said Mr. Seymour.

"*Two hundred and fifty-six feet*," cried Tom, is the depth of the well."

A shout of delight, from the whole juvenile party, announced the satisfaction which they felt at the success of their first experiment in NATURAL PHILOSOPHY.

Louisa observed, that she could not distinguish any interval between the actual contact of the stone with the water and the sound which it produced.

"At so small a distance as two hundred and fifty-six feet," said her father, "the interval could not have exceeded in duration the fourth part of a second, and was, consequently, imperceptible: we might therefore, in the present instance, have accepted the sound as à signal of the stone's arrival at the water, without prejudice to the result of the experiment."

Mr. Seymour told his son, that the method which he had pursued was unobjectionable when the experiment did not extend beyond a few seconds: but that, if a case occurred in which a greater space of time were consumed, he would find his plan tedious; "Now," continued he, "I will give you a general rule that will enable you to obtain the answer in a shorter time without the details of addition. '*The spaces described by a falling body increase as the squares of the times increase.*' I conclude that you already know that the *square* of a number is the sum obtained by multiplying the number into itself."

"Certainly," answered Tom; "the square of 4 is 16; that of 3, 9, and so on."

"This, then, being the case, you have only to square the number of seconds, and then multiply that product by 16, being the space described by the falling body in the first second, and you will have the required answer: apply this rule to the present case; the stone fell to the bottom in four seconds; square this number, 4 × 4 = 16; multiply this by 16, and we obtain 256."

"That," said Tom, "is certainly much more simple than my method."

"And it has the advantage," continued Mr. Seymour, "of being more portable for the memory."

"Should any of the villagers observe us," said Mrs. Seymour, "they will take us for a party of fortune-tellers."

"Of fortune-tellers!" repeated Louisa, with surprise.

"Yes, my dear," replied Mrs. Seymour, "there is a foolish superstition attached to this, and I believe to many other wells in the neighbourhood of remote villages, that by dropping pebbles into it, and observing whether they produce a loud, or only a slight sound, and noticing the number of times they rebound from the sides before they reach the bottom, and other absurd distinctions, a person can predict whether good or evil awaits them."(5)

Mrs. Seymour now proposed the party's return to the Lodge; but Mr. Twaddleton expressed a hope that they would first favour him with a visit at the vicarage; to which proposition they readily assented.

His antiquated residence, mantled in ivy, and shaded by cypress, stood on the confines of the church-yard, from which his grounds were merely separated by a dwarf hedge of sweet-briar and roses; so that the vicar might be said to reside amidst the graves of his departed parishioners, and the turf-clad heap evinced the influence of his fostering care by a grateful return of primroses and violets.

Around the house the reverend antiquary had arranged several precious relics, which were too cumbrous for admission within its walls; amongst these was an ancient cross, raised upon a platform on three steps, which from the worn appearance of the stones had evidently been impressed with the foot of many a wandering pilgrim. These mouldering monuments of ancient days cast a shade of solemnity around the dwelling, and announced its inmate as a person of no ordinary stamp.

Annette, the vicar's trusty servant, had watched the approach of the squire and his family, and, anticipating the honour of a passing visit, was busily engaged in removing the chequed covers from the cumbrous oaken chairs, and the various other bibs and tuckers with which his curiosities were invested, when the party entered the study. Lucky was it for the vicar's repose, that the notice had been so short, or the tidy housewife would, without doubt, have scoured some of the antique commodities, and destroyed a crop of sacred verdure, which ages could not have replenished. As matters stood, nothing was left for poor Annette, but to defend her character at the expense of her master, who she declared treated her as though she was an old witch, whenever she was seen with a *broom*.

"Why, papa," exclaimed Tom, as he cast his eyes around the study, "all these curiosities have been put up since I went to school."

"The boy is right," said the vicar; "I have only just completed their arrangement, and I believe," continued he, addressing himself to Mr. Seymour, "that there are several rich morsels of antiquity which you have not yet seen: but I must, in the first place, introduce my young friends to the wonders of my magic gallery; wherein they may converse with the spirits of departed emperors, heroes, patriots, sages, and beauties;—contemplate, at their leisure, the countenances of the Alexanders, Cæsars, Pompeys, and Trajans;—behold a legion of allegorical and airy beings, who have here, for the first time, assumed appropriate and substantial forms:—examine the models of ancient temples and triumphal arches, which, although coeval with the edifices they represent, are as perfect as at the first moment of their construction, while the originals have long since crumbled into dust. They shall also see volumes of history, condensed into a space of a few inches, and read the substance of a hundred pages at a single glance."

"How extraordinary!" said Tom: "why we

never read any thing more wonderful in our Fairy Tales."

"And what renders it more wonderful," replied the vicar, "is its being all true."

So saying, the antiquary took a key of pigmy dimensions from the pocket of his waistcoat, and proceeded to a cumbrous ebony cabinet which stood in a deep recess, and displayed an antique structure, and curiously carved allegorical devices, in strict unison with that air of mystery with which the vicar had thought proper to invest its contents. It was supported by gigantic eagles' claws; its keyhole was surrounded by hissing snakes; while the head of Cerberus, which constituted the handle, appeared as if placed to guard the entrance. The children were upon the tiptoe of expectation and impatience—the vicar applied the key with the wonder-stirring exclamation of "OPEN SESAMA!"—the lock yielded, and the doors flew open. Disappointment and chagrin were visibly depicted on the countenances of the brother and sisters.

"And so," exclaimed Tom, "this fine magic gallery turns out to be nothing more than a box full of rusty halfpence!"

"I am sure," said Louisa, "it was quite unnecessary to have engaged Cerberus as a sentinel over such rubbish."

"Hush!" cried the vicar; "you talk like one not initiated in the mysteries of enchantment: have you not read, that under its spells the meanest objects have assumed forms of splendour and magnificence?—"

"Like the fabled touch of the Phrygian monarch," said Mrs. Seymour, "which we are told transmuted the meanest materials into gold."

"In like manner, then, may treasures of the greatest value appear to ordinary eyes as mean and worthless."

"This cabinet," continued Mr. Twaddleton, "is under the influence of a potent magician; by the touch of her wand, it would become irradiated as with celestial light, and these rusty coins would be transformed into all those various objects of interest and delight which I had promised to show you."

Tom and Louisa looked at the coins, then at the vicar, and afterwards at Mr. Seymour, to whom they cast an enquiring glance.

"Then pray," exclaimed Tom, "wave this mighty wand of your enchantress, and fulfil your promise."

"The enchantress," replied the vicar, "is not disposed to grant her favours to those by whom she has not been propitiated."

"And what ceremony does she require?" enquired Louisa.

"The perusal of sundry mystic volumes; and the consumption of a midnight lamp at her altar," replied the vicar.

"Do you not comprehend the allegory?" said Mr. Seymour. The enchanted gallery is no other than a collection of antique medals;—the potent enchantress, ERUDITION, or that classical learning, without which they appear of less value than so many rusty halfpence."

"You are right," cried Mr. Twaddleton: "the poetical import of a device can be alone felt and appreciated by those who are acquainted with the classical subjects to which it alludes; for, as Addison forcibly observes, there is often as much thought on the reverse of a medal as in a canto of Spenser; besides, how frequently do you meet with hints and suggestions in an ancient poet, that give a complete illustration to the actions, ornaments, and antiquities which are found on coins?—In short, the person who examines a collection of medals, without a competent knowledge of the classics, is like him who would explore a subterranean cavern without the aid of a torch."

"I have already learned one fact," said Louisa, "with which I was certainly unacquainted; that the ancients possessed a much greater variety of money than modern nations." (6)

"Of that, my dear," replied the vicar, "there is some doubt;—the learned are divided upon the question: some authors maintain that every medal, and even medallion, had its fixed and regular price in payments; while others, on the contrary, assert that we are not in the possession of any real money of the ancients, and that the medals never had any currency as coins. The truth probably is between these two extremes."

"If these medals were not used as money," observed Louisa, "for what purposes could they have been coined?"

"To perpetuate the memory of great actions; and, faithful to its charge of fame, the medal has transmitted events, the history of which must, otherwise, have long since perished. Nay, more," exclaimed the vicar, his voice rising as he became warmed by his subject, "the lamp of history has been often extinguished, and the medalist has collected sparks from the ashes of antiquity which have rekindled its flame. You perceive, therefore," continued the reverend antiquary, "that such collections are of the highest importance, and if your papa will allow you to pass a morning in their examination, I shall easily bring you to admit, that I have not exaggerated the wonders of my magic gallery. I will convince you, that it contains a series of original miniature portraits of the greatest heroes of antiquity; a compendious chart of history, chronology, and heathen mythology; a system of classic architecture; and an accurate commentary upon the more celebrated poems of Greece and Rome. Ay, and I will show you a faithful resemblance of the very ship that carried Æneas to Italy, and of the lofty poop, from which the luckless Palinurus fell into the ocean."

Mr. Twaddleton then favoured Mr. and Mrs. Seymour with a sight of some of those rarer medals, which he considered as constituting the gems of his collection.

"You do not mean to say," exclaimed Tom, as he seized a small coin, "that this *brass* piece is of more value than the large coin of gold that lies next to it?"

"Mercy upon us!" cried the vicar, in a tone of agony, "how the boy handles it!—restore it to its place—gently—gently—that 'little brass piece,' as you call it, is gold, and although it might not have been worth one guinea fifteen hundred years ago, is now valued at a hundred. It is a coin of Ptolemy the 8th of Egypt. On the obverse is the portrait of the king beautifully raised; on the reverse a cornucopiæ. I do not believe that the coin was known to Pinkerton when he wrote his Essay."

"There is, certainly," said Mr. Seymour, "something very inexplicable in the tastes and enthusiastic feelings of you patrons of antiquity."

"The antiquary," observed the vicar, "does not regard a cabinet of medals as a treasure of money, but of knowledge; nor does he fancy any charms in gold, but in the figures that adorn it; it is not the metal, but the erudition, that stamps it with value."

Mr. Twaddleton now passed on to a different compartment of his cabinet, observing that he must exhibit a few of his Roman treasures. "Behold," said he, "two gems of unappreciable value; never do I look upon them but with feelings of the purest delight. Let my young friends come nearer, and inspect them minutely. This is a large brass coin of Tiberius, and was current when Christ was upon the earth; next to it lies a silver *Denarius* of the same Emperor; its value was about equal to sevenpence of our money, and was the coin that tempted Judas to betray his master."

"I think," said Mrs. Seymour, "I have heard you speak of some English coins of rarity and interest."

"True, Madam, very true, but they are in another cabinet: before I close the present one, I will, with your permission, give you a glimpse at my Sulphurs, Paduans, and Beckers."

"Paduans and Beckers!" exclaimed Mr. Seymour, "and pray what may they be? I never before heard the terms."

"'My poverty but not my will consents.' The antiquary who is poor in purse," observed the vicar, "must needs be contented with being rich in counterfeits, or, I ought rather to have said, in possessing copies instead of originals. Becker was an artist of Frankfort, who excelled in imitating ancient coins, but he never used his skill for the purpose of deception, but honestly sold his productions as avowed copies, which are admitted into the cabinets of the curious under the name of '*Beckers*.' The *Paduans*," the vicar added, "derived their name from two brothers at Padua, celebrated for the accuracy with which they imitated large Roman coins. Here are the English coins you alluded to," said the antiquary to Mrs. Seymour. "This is a shilling of Henry VII. curious as being the first shilling ever struck; it was presented to me by a college friend some years ago, and I have been lately informed that it is so rare as to fetch twenty-five pounds; but let me beg you to examine attentively this curious little treasure," said the vicar, his eyes twinkling with pleasure, as he placed the dainty morsel in the hand of Mrs. Seymour; "it is," continued he, "a silver groat of Perkin Warbeck; on one side are the Royal arms, but without a name; they are surmounted, you perceive, with an arched crown, and placed between a fleur de lis and a rose."

"What is the inscription?" asked Mrs. Seymour.

"Say *legend*, Madam, if you please; the words are '*Domine salvum fac regem*, the date 1494. The coin is supposed to have been struck by the order of the Duchess of Burgundy for Perkin Warbeck, when he set out to invade England."

"Pray," said Tom, "have you got a Queen Anne's farthing?"

"It is really curious," observed the vicar, "that well-informed persons should still continue to be deceived with regard to the value of this coin. The absurd notion of its being worth 100*l.* arose from an advertisement of an old lady, who had lost one, stating it to be one of the only three known in the world, and worth at least 100*l.* The truth is, I understand from my much valued friend of Tavistock-Street, that these farthings generally fetch from five to twenty shillings each; there are several different types of them, but the only one intended for currency is that bearing the date of 1714; all the others were struck as patterns. This is certainly scarce, in consequence of the death of the Queen taking place before the coinage was finished. The farthing and sixpence of Oliver Cromwell are much more scarce and valuable, the one generally brings 10*l.* the other as much as 25*l.* It appears that, after Oliver had stamped his head upon them, he was afraid to issue them as current coins, which accounts for the few that have been handed down to us."

"You remind me," said Mr. Seymour, "of a story I lately heard of a crown-piece of Oliver selling at a public auction for as much as two hundred guineas—can it be possible?"

"You labour under a mistake," answered the vicar; "the coin you allude to is known amongst collectors by the name of the Petition crown of Charles the Second, and it is undoubtedly a most inimitable piece of workmanship. The story is this: Simon, the artist, had been employed by Oliver Cromwell, and at the Restoration, in order to obtain the patronage of Charles, executed the crown-piece in question. It resembles in its general appearance the common milled five shilling piece, but on the edging there are two lines of letters beautifully executed. The words are '*Thomas Simon most humbly prays your Majesty to compare this his tryal piece with the Dutch, and if more truly drawn and embossed, more gracefully ordered, and more accurately engraven, to relieve him.*'"

"And what said Charles to it?" enquired Mrs. Seymour.

"Charles," said the vicar, "took no notice of him, on account of his having worked for Cromwell, and the poor artist shortly afterwards died of a broken heart."

"Well," exclaimed Mr. Seymour, "his manes must be surely appeased, if his crowns now sell for two hundred guineas each."

The party, soon after this exhibition, quitted the vicarage, highly gratified, and returned to the lodge, where, after the usual ceremonies at the toilet, they sat down to dinner; in the enjoyment of which we will now leave them, and put an end to the present chapter.

## CHAPTER III.

MOTION—ABSOLUTE AND RELATIVE.—UNIFORM, ACCELERATED, AND RETARDED VELOCITY.—THE TIMES OF ASCENT AND DESCENT ARE EQUAL.—VIS INERTIÆ.—ACTION AND REACTION ARE EQUAL AND IN OPPOSITE DIRECTIONS.—MOMENTUM DEFINED AND EXPLAINED.—THE THREE GREAT LAWS OF MOTION.

"The table-cloth is removed," cried Tom, as he cast a sly glance through the open window of the dining-room.

"It is, my boy," replied Mr. Twaddleton; "*Diffugere nives*, as the poet has it."

"*Et redeunt jam gramina campis*," added Mr. Seymour, as he pointed to the green cloth with which the table was covered.

"*Et decrescentia flumina*," continued the vicar, with a smile; "but, psha! enough of wine and quotation. Come, let us join the children."

Mr. Twaddleton, accompanied by Mr. and Mrs. Seymour, and Louisa, rose from the table, and proceeded to the lawn.

"The gravitation of Tom's ball," said Mr. Seymour, "furnished an ample subject for our morning's diversion, let us try whether its other motions will not suggest further objects of enquiry."

"I well remember," observed Louisa, "that Mrs. Marcet extols that apple, the fall of which attracted the notice of Sir Isaac Newton, above all the apples that have ever been sung by the poets: and she declares, that the apple presented to Venus by Paris; the golden apples by which Atalanta won the race; nay, even the apple which William Tell shot from the head of his own son, cannot be brought into comparison with it."

"Well said! Mrs. Marcet," exclaimed Mr. Seymour; "upon my word, had the mother of mankind used but half such eloquence in praise of an apple, we cannot wonder at its influence."

"What honours, then," continued Louisa, "shall we decree to Tom's ball, if it instructs us in the first principles of philosophy?"

"We are trifling," observed Mr. Seymour, and so saying, he took the ball from Tom's hand, and rolling it along the ground, exclaimed, "there it goes, performing, as you may perceive, two different kinds of motion at the same time; it turns round, or revolves on its *axis;* and goes straight forward, or to speak more philosophically, performs a *rectilinear* motion."

Tom said that he did not exactly comprehend what was meant by the *axis.* (7) His father, therefore, informed him that the axis of a revolving body was an imaginary line, which was itself at rest, but about which all its other parts turned, or rotated: "But," continued he, "can you tell me whether you understand what is meant by the word *motion?*"

"If he can," exclaimed the vicar, "he is a cleverer fellow than the wisest philosopher of antiquity, who, upon being asked the very same question, is said to have walked across the room, and to have replied, 'You see it, but what it is I cannot tell you.'"

"Your ancient acquaintances," observed Mr. Seymour, "entertained some very strange notions touching this said subject of motion. If I remember right, Diodorus denied its very existence; but, we are told that he did not himself remain *unmoved,* when he dislocated his shoulder, and the surgeon kept him in torture while he endeavoured to convince him, by his own mode of reasoning, that the bone could not have moved out of its place: we have, however, at present, nothing to do with the ancients; the philosophers of our own times agree in defining motion to be '*the act of a body changing its situation with regard to any other;*' and you will therefore readily perceive, that this may actually happen to a body while it remains absolutely at rest."

"Well, that beats all the paradoxes I ever heard," cried Tom; "a body then may be in motion, while it is at rest."

"Certainly," replied Mr. Seymour; "it may be *relatively* in motion, while it is *absolutely* at rest."

"How can a body change its place," said Louisa, "except by moving?"

"Very readily," answered her father; "it may have its relative situation changed with respect to surrounding objects; there is your ball, and here is a stone, has not each of them a particular situation with respect to the other; and by moving one, do I not change the *relative* situation of both?"

"I perceive your meaning," said Tom.

"To prevent confusion, therefore, in our ideas, it became necessary to distinguish these two kinds of motion from each other by appropriate terms; and, accordingly, where there has been an actual change of place, in the common meaning of the term, the motion which produced it is termed ABSOLUTE motion; whereas, on the contrary, when the situation has been only relatively changed, by an alteration in the position of surrounding bodies, the motion is said to be RELATIVE."

"Surely, papa," said Louisa, "no person can ever mistake *relative* for *absolute* motion; what then is the use of such frivolous distinctions? When a body really moves, we can observe it in the act of changing its place, and no difficulty can arise about the matter."

"Nothing, my dear, is more fallacious than our vision; the earth appears motionless, and the sun and stars *seem* as if they revolved round it; but it is scarcely necessary for me to inform you that our globe is constantly moving with considerable velocity, while the sun remains at rest.—Mr. Sadler, the famous aëronaut," continued Mr. Seymour, "informed me, that he was never sensible of the motion of the balloon in any of his excursions, but that, as he ascended into the air, the earth always appeared as if sinking beneath him, and as he descended, as if rising to meet him."

Mr. Twaddleton here observed, that he had heard a very curious anecdote, when he was last in London, which fully confirmed the truth of Mr. Sadler's statement. "An aëronaut," said he, "whose name I cannot at this moment recollect, had recently published a map of his voyage, and, instead of proceeding in any one line of direction, his track absolutely appeared in the form of circles, connected with each other like the links of a chain: this occasioned considerable astonishment, and, of course, some speculation, until it was at length discovered, that his apparent journey was to be attributed to the rotatory motion of the balloon, which the voyager, not feeling, had never suspected."

"And what," asked Tom, "could have been the reason of his not having felt the motion?"

His father explained to him, that we are only conscious of being in motion when the conveyance, in which we are placed, suffers some impediment in its progress. "If," said he, "you were to close your eyes, when sailing on calm water, with a steady breeze, you would not perceive that you were moving: for you could not *feel* the motion, and you could only *see* it, by observing the change of place in the different objects on the shore; and then it would be almost impossible, without the aid of reason and experience, to believe that the shore itself was not in motion, and that you were at rest."

Mrs. Seymour here repeated the following passage from that interesting novel "Anastasius," which she observed was beautifully descriptive of the illusive appearance to which their papa had just referred :—

"The gradually increasing breeze carried us rapidly out of the Straits of Chio. The different objects on the shore,—mountains,—valleys,—villages,—and steeples,—seemed in swift succession first advancing to meet us, then halting an instant alongside our vessel, as if to greet us on our passage, and, lastly, again gliding off with equal speed; till, launched into the open main, we saw the whole line of coast gradually dissolve in distant darkness."

"That is indeed a beautiful and very apposite illustration," said Mr. Seymour; "and I think Louisa will now admit, that it is not quite so easy, as she at first imagined, to distinguish between *Absolute* and *Relative* motion."

As the children now understood what was meant by the term *Motion*, their father asked them whether they could tell him what produced it.

"I can make a body move by various means," answered Tom.

"But they may all be reduced to one," said Mr. Seymour; "viz. some exertion which is called *Force;* thus the *force* of my hand put your ball in motion; while gravitation was the *force* which made it fall to the earth; and I must, moreover, inform you, that a body always moves in the direction of the force which impels it, and with a velocity, or rate of motion, which is proportional to its degree, or strength; and, were there no other forces in action but that which originally produced the motion, the body would proceed onwards in a right line, and with a *uniform* velocity for ever."

"For ever!" exclaimed Louisa.

"Ay, my dear, *for ever;* but we will discuss that question presently; you must first tell me whether you understand what is meant by *uniform* velocity."

"I suppose that *uniform* velocity is that which is regular, and of an equal rate throughout."

"Philosophers," replied her father, "call the motion of a body *uniform*, when it passes over equal spaces in equal times.—Now, Tom, it is your turn to answer a question. Can you describe the meaning of the terms *Accelerated* and *Retarded* motion?"

"I conclude that motion is said to be *accelerated* when it moves every moment quicker and quicker; and to be *retarded* when it moves slower and slower."

"You are perfectly right; and gravity may either act in occasioning the one or the other: our experiment at the well this morning afforded you an example of gravity producing a regularly accelerated motion. I did not fully explain the fact at the time, because I was desirous of avoiding too many new ideas at once; we must win our way slowly and cautiously through the mazes of philosophy: I will, however, now endeavour to give you as clear an explanation as the subject will allow.—It is, I think, evident, that if, at the moment you dropped the stone from your hand, the force of gravity could have been suspended, it would have descended to the bottom of the well with a uniform velocity; because there could have been nothing either to accelerate or retard its motion. But this was not the case, for the power of gravity was in constant operation; and, if you keep this fact in mind, you will readily understand how the velocity became accelerated: for, suppose the impulse given by gravity to the stone, during the first instant of its descent, be equal to *one*, the next instant we shall find that an additional impulse gives the stone an additional velocity equal to *one*, so that the accumulated velocity is now equal to *two*; the following instant, again, increases the velocity to *three*, and so on till the stone reaches the bottom."

Mr. Twaddleton observed, the fact might be shortly expressed by saying, that "the effects of preceding impulses must be added to subsequent velocities."

Mr. Seymour then remarked that the same explanation would apply to *retarded* velocity. "If," said he, "you throw a stone perpendicularly upwards, the velocity will be as much *retarded*, as it was in the other case *accelerated*, by gravity; the consequence of which is that it will be exactly the same length of time ascending that it was descending."

"I should have thought the very reverse," cried Louisa, "and that it would have fallen quicker than it rose."

"You have forgotten to take into account the force with which the stone is projected upwards, and which is destroyed by gravity before it begins to descend."

"Certainly," answered Louisa; "but the force given to a stone in throwing it upwards, cannot always be equal to the force of gravity in bringing it down again; for the force of gravity is always the same, while the force given to the stone is entirely optional. I may throw it up gently or otherwise, as I please."

"If you throw it gently," said her father, "it will not rise high, and gravity will soon bring it down again; if you throw it with violence, it will rise much higher, and gravity will be longer in bringing it back again to the ground. Suppose, for instance, that you throw it with a force that will make it rise only sixteen feet; in that case, you know it will fall in one second of time. Now it is proved by experiment, that an impulse requisite to project a body sixteen feet upwards, will make it ascend that height in one second of time; here, then, the times of ascent and descent are equal. But, supposing it be required to throw a stone twice that height, the force must be proportionally greater. You see, then, that the impulse of projection, in throwing a body upwards, is always equal to the action of the force of gravity during its descent; and that it is the greater or less distance to which the body rises that makes these two forces balance each other."

"Thank you," dear papa, "for the pains you have taken in explaining this subject to us."

"Nay," replied Mr. Seymour, "bestow your thanks upon those to whom they are more justly due; Mrs. Marcet is entitled to the merit of this explanation; for I obtained it from her 'Conversations.' Before I quit this subject, I would just observe that, when we come to the consideration of the bow and arrow, you will, by the application of the law I have endeavoured to expound, be enabled to ascertain the height to which your arrow may ascend, with the same facility as you discovered the depth of the well: for, since the times of ascent and descent are equal, you have only to determine the number of seconds which intervene between the instant at which the arrow quits the bow to that at which it falls to the ground, and halving them, to make the usual calculation.—But let us proceed to another subject. Roll the ball hither, Tom; roll the ball hither, I say! you stand as if you thought it would advance to us of its own accord."

"I know a little better than that, too," cried Tom; "no body can move without the application of some force."

"Nor stop, either," added Mr. Seymour, "when it is once in motion; for matter is equally indifferent to both rest and motion."

"And yet, papa," cried Louisa, "unfortunately for your assertion, the ball stopped just now, and I am sure that no force was used to make it do so."

"And pray, Miss Pert, why are you so sure that no force was opposed to its progress? I begin to fear that my lesson has been thrown away upon you, or you would not, surely, have concluded so falsely."

The vicar here interposed, observing that, simple as the question might appear to those who had studied it, the fact was so contrary to every thing that passed before us, that Mr. Seymour ought not to feel any surprise at the scepticism of his daughter; he begged to remind him that the truth, apparent as it doubtless now was, lay hid for ages before the sagacity of Galileo brought it to light.

Mr. Seymour admitted the justice of this remark, and proceeded in his explanation.

"I think," said he, "you will readily allow that matter cannot, in itself, possess any power of changing its condition: it can, therefore, no more destroy, than it can originate its own motion; when it is at rest, it must ever remain so, unless some force be applied that can impart to it activity; and, when once in motion, it must continue to move until some counteracting force stops it. To believe otherwise you must suppose that matter possesses in itself a power to alter its condition, which is perfectly absurd."

"And yet," said Tom, "when I see my ball or marble stop of its own accord, how can you blame me for believing it possible?"

"Your difficulty arises from your ignorance of the existence of certain forces which act upon the rolling ball or marble. Its progress, as it rolls along, is impeded and ultimately stopped by the rubbing, or friction occasioned by its passage over the ground; and this will be greater or less, according to the degree of roughness of the surface; if it be small, the ball will continue for a longer time in motion; you must have observed, that your marble has always rolled much farther on a smooth pavement than on a rough gravel walk."

"Certainly," said Tom, "and I well remember that when we played at *ring-taw* last winter on the ice, we were obliged, for this very reason, to extend the usual boundaries."

"Is it not evident, then, that the motion of a body is stopped by some opposing force; and that, if this could be entirely removed, the body would continue to move for ever?"

Tom and Louisa both admitted the justness of the argument; but, at the same time, would have been better satisfied if the fact could have been proved by actual experiment. Mr. Seymour told them that the perpetual revolution of the earth and heavenly bodies afforded a proof which ought to satisfy them; and, especially, since it agreed with those views which were proved to be true by an examination of what took place on the surface of our own globe.

We will, therefore, with the permission of our readers, consider this point as settled, and proceed with the young philosophers to the investigation of some other topics connected with the doctrine of motion.

"Since a body at rest," said Mr. Seymour, "can only be set in motion, or, when in motion, be brought to rest, by the impression of some force, it must follow, that it can only move in the direction in which such a force may act; and, moreover, that the degree of motion, or the *velocity* must, other things being equal, be in proportion to the degree of force used."

"Why, truly," cried the vicar, "my young friends must of necessity admit that fact; for the body, not having any will of its own, as you say, must needs, if it move at all, go the road it is driven."

"Yes," added Mr. Seymour, "and it must go with a velocity in proportion to the force with which it is driven."

"Doubtless, doubtless," cried the vicar, "you admit that also; do you not, my young friends and playmates?"

It is hardly necessary to state, that the children instantly assented to these propositions. The vicar had placed them in so clear and popular a point of view, as to be intelligible to the lowest capacities.

"With these admissions, then, my dear children," said their father, "I shall have but little difficulty in convincing you of the truth of the other laws by which the direction of moving bodies is governed. At present, however, it is not my intention to enter upon this subject; you have some preliminary knowledge to acquire before you can understand what is termed the *Composition and Resolution of Forces*."

"I shall not easily forget," said Louisa, "that matter is perfectly passive, and that it can neither put itself in motion when at rest, nor stop itself when in motion."

"This indifference to rest or motion," replied Mr. Seymour, "has been termed the *Vis Inertiæ* of matter."

"A very objectionable term,—a very puzzling expression," exclaimed the vicar;—"to denote a mere state of passive indifference by the term *Vis*, or power, does appear to me, who have been in the habit of connecting words with ideas, as excessively absurd."

"I allow," said Mr. Seymour, "that the simple word *Inertia* would have been more correct; but we are bound to receive an expression which has been long current. I suppose, however, you know that the addition of *Vis* originated with Kepler, who, like my boy Tom, could not help thinking that the disposition of a body to maintain its motion, or state of rest, indicated something like power; but we will not waste our time upon verbal disquisitions. It is clear, that matter, at rest, resists being put in motion; the degree of that resistance is always in proportion to the degree of force applied to put it in motion; or, to speak more philosophically, that *Action and Re-action are equal, and in opposite directions.*"

"You, surely, do not mean to say," exclaimed Tom, "that if I strike my marble, the marble strikes my hand, with the same force in return?"

"Precisely; that is my meaning."

"What!" cried Louisa, "if a man strikes another on the face with his hand, do you seriously maintain, that both parties suffer the same pain?"

"Oh, no, no," said Tom, "papa can never intend to say that; I am quite sure, if it were the case, Mr. Pearson would not be so fond of boxing our ears."

Mr. Seymour answered this question, by observing that, if the hand possessed the same degree of feeling as the face, they would both suffer equally under the conflict. "If," continued he, "you strike a glass bottle with an iron hammer, the blow will be received by the hammer and the glass; and it is quite immaterial whether the hammer be moved against the bottle at rest, or the bottle be moved against the hammer at rest, yet the bottle will be broken, though the hammer be not injured; because the same blow which is sufficient to shiver the glass is not sufficient to break or injure a lump of iron. In like manner, the blow that is sufficient to pain your sensitive face, and make your ears tingle, will not occasion the least annoyance to the obtuse hand of your preceptor. The operation of this law," continued Mr. Seymour, "will be exemplified in every step of our progress. When the marble, as it rolls along, strikes any obstacles, it receives, in return, a corresponding blow, which will be found to influence its subsequent direction. The peg of the top, as it rubs on the ground, is as much influenced by the friction, as if a force were actually applied to it when in a state of rest; and when we consider the forces by which the kite is made to ascend into the air, you will learn, from the same law, the nature of that advantage which you derive from running with it."

The vicar observed that the subject of *Momentum* might be introduced, and advantageously explained, upon this occasion.

"Momentum," said Tom; "and pray what is that?"

"It is a power," replied his father, "intimately connected with motion; and, therefore, as your friend, the vicar, justly remarks, may be very properly introduced before we quit that subject.—It is the force with which a body in motion strikes against another body."

"That," observed Tom, "must of course depend upon the velocity of the body's motion."

"Undoubtedly, my dear; the quicker a body moves, the greater must be the force with which it would strike against another body; but we also know that the heavier a body is, the greater also will be its force; so that *momentum*, you perceive, must have a relation to both these circumstances, viz. velocity, and weight; or, to speak more correctly, *the momentum of a body is composed of its quantity of matter, multiplied by its quantity of motion:* for example, if the weight of a body be represented by the number 3, and its velocity also by 3, its *momentum* will be represented by $3 \times 3 = 9$; so that, in producing momentum, increased velocity will always compensate for deficiency of matter, and a light body may thus be made a more effective force than a heavy one, provided that its velocity be proportionally increased; thus, a small ball weighing only *two pounds*, and moving at the rate of *five hundred feet* in a second, will produce as much effect as a cannon ball of *ten pounds* in weight, provided it moved only at the rate of a *hundred feet* in the same time."

"Let me see," cried Tom, "whether I understand your statement. We must multiply, as you say, the weight by the velocity; the weight of the small ball you state at two pounds, and it travels at the rate of five hundred feet in a second; then its momentum must be a thousand. The weight of the great ball is ten pounds, its velocity only a hundred feet, then its momentum must also be a thousand; because, in both cases, the sums multiplied into each other will give the same product."

"Exactly: and thus you perceive that the small ball becomes an exact balance to the larger one; the first making out in motion what it wanted in matter, while the latter makes out in matter what it wanted in motion. I wish you to keep this law of *Momentum* in your remembrance; upon it depends the action of all the *mechanical powers* (8), as they are termed."

"I have heard," said Louisa, "that a feather might be made to produce as much havoc as a cannon shot, if you could give it sufficient velocity."

"Unquestionably: but there is a practical difficulty in the attempt, from the resistance of the air, which increases, as you have already seen in the experiment of the paper and penny-piece (p. 31), as the weight of a body decreases. Were it not for this resistance of the air, a hailstone falling from the clouds would acquire such a momentum, from its accelerated velocity, as to descend like a bullet from a gun, and destroy every thing before it; even those genial showers which refresh us in the spring and summer months, would, without such a provision, destroy the herbage they are so well calculated to cherish. Had the elephant possessed the mobility of the beetle, it would have overturned mountains. From this view of the subject of Momentum," continued Mr. Seymour, "you will easily understand why the immense battering rams, used by the ancients, in the arts of war, should have given place to cannon balls, of but a few pounds in weight. Suppose, for example, that the battering ram of Vespasian weighed 100,000 pounds, and was moved, we will admit, with such a velocity, by strength of hands, as to pass through 20 feet in one second of time, and that this was found sufficient to demolish the walls of Jerusalem, can you tell me with what velocity a 32-pounder must move to do the same execution?"

"I will try," said Tom, as he took out his pencil and pocket-book to make the calculation. "The momentum of the battering ram must be estimated by its weight, multiplied into the space passed over in a second of time; which is 100,000 multiplied by 20; that will give 2,000,000. Now, if this momentum, which must also be that of the cannon ball, be divided by the weight of the ball, it will give the velocity required, which I make out to be 62,500 feet."

"Admirably calculated," said Mr. Seymour: "and I will take care, my dear Tom, that your intelligence shall be suitably rewarded."

Mr. Twaddleton here observed, that he thought "his young friends and playmates" must have received, for that day, as much philosophy as they could conveniently carry away without fatigue. Mr. Seymour concurred in this observation; and the more readily, as the path they had to travel was rugged, and beset with difficulties. "I will, therefore," said he, "not impose any farther burthen upon them; but I will assist them in tying, into separate bundles, the materials which they have collected in their progress, in order that they may convey them away with greater ease and security. Know then, my dear children," said the affectionate parent, "that you have this day, been instructed in the three great Laws of Motion, viz.

I. *That every body will continue in a state of rest, until put into motion by some external force applied to it, and if that force be single, the motion so produced will be rectilinear, i. e. in the direction of a straight line.*

II. *Change of Motion is always proportional to the moving force impressed, and is always made in the direction of the right line in which the force acts.*

III. *Action and Reaction are equal, in equal quantities of matter, and act in contrary directions to each other.*

# CHAPTER IV.

A SAD ACCIDENT TURNED TO A GOOD ACCOUNT.—ONE EXAMPLE WORTH A HUNDRED PRECEPTS.—THE CENTRES OF MAGNITUDE AND GRAVITY.—THE POINT OF SUSPENSION.—THE LINE OF DIRECTION.—THE STABILITY OF BODIES, AND UPON WHAT IT DEPENDS.—METHOD OF FINDING THE CENTRE OF GRAVITY OF A BODY.—THE ART OF THE BALANCER EXPLAINED AND ILLUSTRATED.—VARIOUS BALANCING TOYS.

Just as Mr. Seymour was, on the following morning, stepping upon the lawn, with the intention of joining his children, Rosa and Fanny both made their appearance completely drenched with water, and dripping like mermaids.

"Heyday!" exclaimed their father, "how has this misfortune happened?"

"Do not be angry, papa," said Tom; "indeed, indeed, it was an accident. Fanny, observing the water-cart in the garden, had just begun to wheel it forward, when the water rushed over her like a wave of the sea, and, upon stopping the cart, it flew over with equal force on the opposite side, and deluged poor Rosa, who was walking in front of it."

"Well, well; lose no time in changing your clothes, and meet me again in half an hour."

At the appointed time the children reassembled on the lawn.

"And so then," said their father, "I perceive that my philosophical lesson of yesterday has been entirely lost upon you."

The children were unable to comprehend the meaning of this rebuke; but Mr. Seymour proceeded:—

"I trust, however, that the accident of this morning will serve to impress it more forcibly upon your memory: one example is better than a hundred precepts."

Tom was more puzzled than ever.

"You have met with an accident; I will endeavour to convert it into a source of instruction, by showing you how the principles of natural philosophy may be brought to bear upon the most trivial concerns of life. You learned yesterday, that a body at rest offers a resistance to any force that would put it in motion, and that, when in motion, it equally opposes a state of rest; now let us apply this law for the explanation of the accident that has just befallen you. The butt was full of water; when you attempted to wheel it forward, the water resisted the motion thus communicated to the vessel, and from its *vis inertiæ*, or effort to remain at rest, rose up in a direction contrary to that in which the vessel moved, and consequently poured over; by this time, however, the mass of fluid had acquired the motion of the cart, when you suddenly stopped it, and the water in endeavouring to continue its state of motion, from the same cause that it had just before resisted it, rose up on the opposite side, and thus deluged poor Rosa."

Louisa was quite delighted with this simple and satisfactory application of philosophy, and observed, that she should not herself mind a thorough soaking, if it were afterwards rewarded by a scientific discovery.

"I will give you, then, another illustration of the same law of motion," said Mr. Seymour, "which, instead of explaining an accident, may, perhaps, have the effect of preventing one. If, while you are sitting quietly on your horse, the animal starts forward, you will be in danger of falling off *backward;* but if, while you are galloping along, it should stop suddenly, you will inevitably be thrown *forward* over the head of the animal."

"I clearly perceive," said Louisa, "that such would be my fate under the circumstances you state."

"Now, then, my dear children, since our friend the vicar cannot attend us at present, suppose we retire to the library, where I have an interesting experiment to perform, and a new toy ready for your inspection.

In compliance with their father's wishes, the children cheerfully returned to the library, when Mr. Seymour presented Louisa with a BANDILOR. Most of our readers are, doubtless, acquainted with this elegant toy. It consists of two discs of wood, united to each other by a small axis, upon which a piece of string is affixed. When this string is wound round the axis, and the bandilor is suffered to run down from the hand, the end of the string being held by a loop on the fore finger, its momentum winds up the string again, and thus it will continue for any length of time to descend from, and ascend to, the hand. It affords a good example of the operation of *vis inertiæ*, or what may, with equal propriety, be termed *the momentum of rotatory motion*. Its action may be compared to that of a wheel, which, running down a hill, acquires sufficient momentum to carry it up another. There are several toys which owe their operation to the same principle, of which we may particularize the windmill, whose fliers are pulled round by a string affixed to the axis of the sails. In playing with the bandilor, a certain address is required to prevent the sudden check which the toy would otherwise receive, when it arrived at the end of the string, and which would necessarily so destroy its momentum as to prevent its winding itself up again. Mr. Seymour now informed his young pupils that he had an experiment to exhibit, which would further illustrate, in a very pleasing manner, the truth of the doctrine of *vis inertiæ.* He accordingly inverted a wine-glass, and placed a shilling on its foot; and, having pushed it suddenly along the table, the coin flew off, towards the operator, or in a direction opposite to that in which the glass was moving. He then replaced the shilling, and imparted to the glass a less sudden motion; and, when it had acquired sufficient velocity, he checked it, and the coin darted forward, leaving the glass behind it.

Louisa, upon witnessing this experiment, observed that she felt satisfied of the correctness of her father's statement, when he told her that, if the horse suddenly started forward, when she was at rest, she would be thrown off behind, and that if it should suddenly stop on the gallop, she would be precipitated over its head. The children now arranged themselves around the table, in order to consider several curious toys which Mr. Seymour had collected for the purpose of explaining the nature of the *Centre of Gravity.*

"But, in the first place," said Mr. Seymour, "can you tell me, Tom, what is meant by *The Centre of Gravity?*"

"Its central point," answered the boy.

"Certainly not; the central point is termed its centre of *magnitude,* not that of gravity; and it is only when a body is of uniform density, and regular figure, that these centres of magnitude and gravity coincide, or fall in the same spot."

"I now remember," cried Tom, "that the centre of gravity is that point, about which all the parts of a body exactly balance each other."

"Now you are right; it is, in other words, that point in which the whole weight, or gravitating influence, of a body is, as it were, condensed or concentrated, and upon which, if the body be freely suspended, it will rest with security; and consequently, as long as this centre is supported, the body can never fall; while, in every other position, it will endeavour to descend to the lowest place at which it can arrive."

"Have all bodies, whatever may be their shape, a centre of gravity?" asked Louisa.

"Undoubtedly."

"And you say," continued Louisa, "that every body will fall, if this point is not supported."

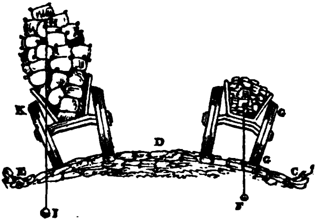
"Infallibly. And now, Tom," said Mr. Seymour, "can you tell me what is meant by the *line of direction?*"

The young philosopher was unable to answer this question, and his father, therefore, informed him that, if a perpendicular line were drawn from the centre of gravity of a body to the centre of the earth, such a line would be termed the *line of direction;* along which every body, not supported, endeavours to fall; and he was also informed that, if this said line fell within the base of a body, such a body was sure to stand; but never otherwise.

Louisa observed that she was not quite sure she understood her papa's meaning, and therefore begged for further explanation.

"I will exemplify it, then," replied Mr. Seymour, "by a drawing. *Fig.* 10. represents a load of stones in a cart moving upon the sloping road C D E; this load, being low down in the cart, B will represent its centre of gravity, and B F its line of direction, which, you perceive, falls much within the supporting or lower wheel G; and there cannot, therefore, be any danger of such a cart being

*Fig.* 11. *Fig.* 10.



overturned; but in *fig.* 11, the centre of gravity is raised from its former position to H, and H I is now the line of direction; which, falling without the base, or wheel K, the load will not be supported, and must consequently fall. These figures," added Mr. Seymour, "will also explain a fact which you must have frequently observed, that a body is stable or firm in proportion to the breadth of its base; hence the difficulty of sustaining a tall body, like a walking stick, upon its narrow base; or that of balancing a hoop upon its edge, or a top upon its point; while, on the contrary, it is almost impossible to upset the cone or the pyramid, since, in the latter cases, the *line of direction* falls within the middle of the base, the centre of gravity of the body being necessarily low."

"I suppose," observed Louisa, "that this is the reason why carriages, when too much loaded, are so apt to upset."

"Say, when too much loaded on their *tops*, and you will be right. As you now, I trust, understand this part of the subject, let us proceed a step farther; if you take any body, with a view to suspend it, is it not evident, that if it be suspended by that point in which the centre of gravity is situated, it must remain at rest in *any* position indifferently?"

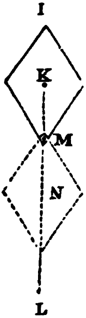
"I thought," said Tom, "we had already settled that question."

"True, my dear boy; but there is another question of great importance arising out of it, and which you have not yet considered: tell me, should the body be suspended on any other point, in what position it can rest?"

"I do not exactly understand the question."

"There are," replied his father, "only two positions in which it could rest, either where the centre of gravity is exactly *above*, or exactly *below*, the point of suspension; so that, in short, this point shall be in the *line of direction*. Where the point of suspension is *below* the centre of gravity, it is extremely difficult to balance or support a tall body by such a method, because the centre of gravity is always endeavouring to get under the point of support. Look at this diagram, and you will readily comprehend my meaning. K is the centre of gravity of the diamond-shaped figure, which may be supported, or balanced, on a pin passing through it at M, as long as the centre of gravity K is immediately over the point of suspension M: but if that centre is removed in the slightest degree, either to the right or left of its place K, the body will no longer retain its erect position I K L, but it will revolve upon M, and place itself in the situation indicated by the dotted lines beneath the point M: and its centre of gravity will now be removed to N, directly *under* M, and in the line K L, which, as you well know, is the line of direction. Have I rendered myself intelligible?"

*Fig* 12.



"I understand it perfectly," answered Tom.

"And do you also, my dear Louisa?"

Louisa's answer was equally satisfactory, and Mr. Seymour went on to state that the information they had now acquired, would enable them to ascertain the situation of the centre of gravity of any plane surface which was portable, notwithstanding it might possess the utmost irregularity of shape.

"You shall, for example," continued he, "find the centre of gravity in your kite."

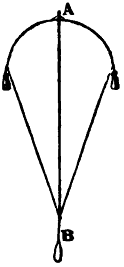
"I cannot say," observed Tom, "how I should set about it."

" Well, fetch your kite, and I will explain the method."

Tom soon produced it, and the tail having been removed, Mr. Seymour proceeded as follows:—

" I now," said he, " suspend the kite by the loop at its bow, and since it is at rest, we know that the centre of gravity must be exactly below the point of suspension; if, therefore, we draw a perpendicular line from that point, which may be easily done by a plumb-line, with a weight attached to it, such a line will represent the *line of direction*, as indicated by A B in *fig.* 13."

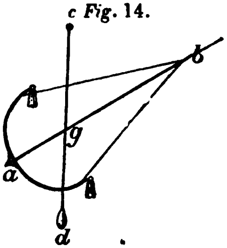
*Fig.* 13.



" It is clear enough," said Tom, " that the centre of gravity must lie in the line A B, but how are we to find in what part of it?"

" By suspending the kite in another direction," answered Mr. Seymour, who then hung it up in the position represented at *fig.* 14., " and then by drawing another perpendicular from the new point of suspension."

*Fig.* 14.



‘ The centre of gravity," said Louisa, " will in that case be in the line *c d*, as it was before in that of *a b*."

" In both the lines!" exclaimed Tom, with some surprise; " it cannot be in two places."

" And therefore," added Mr. Seymour, " it must be in that point, in which the lines meet and cross each other: so saying, he marked the spot *g* with his pencil, and then told his little scholars, that he would soon convince them of the accuracy of the principle. He accordingly placed the head of his stick upon the pencil mark, and the kite was found to balance itself with great exactness."

"True, papa," said Tom, "that point must be the centre of gravity, for all the parts of the kite exactly balance each other about it."

"It is really," observed Louisa, "a very simple method of finding the centre of gravity."

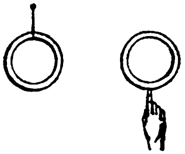
"It is," said Mr. Seymour; "but you must remember that it will only apply to a certain description of bodies: when they are not portable, and will not admit of this kind of examination, their centres of gravity can only be ascertained by experiment or calculation, in which the weight, density, and situation of the respective materials must be taken into the account. Having proceeded thus far, you have next to learn that the centre of gravity is sometimes so situated as not to be *within* the body, but actually at some distance from it."

"Why, papa!" exclaimed Tom, "how can that possibly happen?"

"You shall hear. The centre of gravity, as you have just said, is that point about which all the parts of a body balance each other: but it may so happen that there is a vacant space at this point. Where, for example, is the centre of gravity of this ring? Must it not be in the space which the ring encircles?"

"I think it must," said Tom; "and yet how can it be ever supported without touching the ring?"

"That point cannot be supported," answered his father, "unless the ring be so held that the line of direction shall fall within the base of the support, which will be the case whether you poise the ring on the tip of your finger, or suspend it by a string, as represented in the figures which I have copied from the 'Conversations on Natural Philosophy.' I need scarcely add, that it will be more stably supported in the latter position, because the centre of gravity is below the point of suspension; whereas, in the former the base is extremely narrow, and it will, consequently, require all the address of the balancer to prevent the centre of gravity from falling beyond it. As you are now in possession of all the leading principles upon which the operations of the centre of gravity depend, I shall put a few practical questions to you, in order that I may be satisfied you understand them. Tell me, therefore, why a person who is fearful of falling, as, for instance, when he leans forward, should invariably put forward one of his feet, as you did the other day, when you looked into Overton well?"



"To increase his base," answered Tom; "whenever I lean greatly forward, I should throw the line of direction beyond it, did I not at the same instant put out one of my feet, so as to extend my base, and thus to cause the line to continue within it."

"Rightly answered; and, for the same reason, a porter with a load on his back leans forward, to prevent his burthen from throwing the line of direction out of the base behind. Did you ever observe the manner in which a woman carries a pail of water?"

"To be sure," said Tom; "she always stretches out one of her arms."

"The weight of the pail," continued Mr. Seymour, "throws the centre of gravity on one side, and the woman, therefore, stretches out the opposite arm, in order to bring it back again into its original situation; but a pail hanging on each arm is carried without difficulty, because they balance each other, and the centre of gravity remains supported by the feet."

"I see," said Louisa, that all you have said about the woman and her pail must be true; but how could she have learned the principle which thus enabled her to keep the centre of gravity in its proper place?"

"By experience. It is very unlikely that she should ever have heard of such a principle, any more than those people who pack carts and waggons, and yet make up their loads with such accuracy as always to keep the line of direction in, or near the middle of the base. But to proceed to another example—have I not frequently cautioned you against jumping up suddenly in a boat? Can you tell me upon what principle such an operation must be attended with danger?"

"I suppose," said Tom, "for the very same reason that a waggon is more likely to be overturned when its top is too heavily laden; it would elevate the centre of gravity, and thereby render the line of direction liable to be thrown beyond the base, and so upset the boat."

Mr. Seymour observed, that after this lesson he thought the balancing which Tom and Louisa had witnessed at Astley's theatre, last year, would cease to appear so miraculous. Louisa declared that she had now discovered the whole mystery.

"You have doubtless perceived," said her father, "that the art entirely consists in dexterously altering the centre of gravity upon every new position of the body, so as constantly to preserve the line of direction within the base. Rope-dancers effect this by means of a long pole, the ends of which are loaded by weights, and which they hold across the rope. If you had paid sufficient attention to their movements, you must have perceived how steadily they fixed their eyes on some object near the rope, so as to discover the slightest deviation of their centre of gravity to one or the other of its sides, which they no sooner detect, than they instantly rectify it by a countervailing motion of their pole, and are thus enabled to preserve the line of direction within the narrow base. This very same expedient is frequently practised by ourselves; if we slip or stumble with one foot, we naturally extend the opposite arm, making the same use of it as the rope-dancer does of his pole. Many birds, also, by means of their flexible necks, vary the position of their centre of gravity in the same manner. When they sleep, they turn it towards the back, and place it under the wing, in order to lay the greatest weight on the point above the feet."

"What an interesting subject this is," cried Louisa, "and how many curious things it is capable of explaining!"

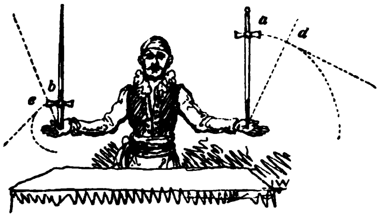
"Indeed is it; and I shall take an opportunity of pointing out several specimens of art (9) which are indebted for their stability to the scientific application of the principle we have been considering; —but I have now a paradox for you, Tom.

"Let us hear it, papa."

"How comes it that a stick, loaded with a weight at the upper extremity, can be kept in equilibrio, on the point of the finger, with much greater ease than when the weight is near the lower extremity; or, for instance, that a sword can be balanced on the finger much better, when the hilt is uppermost?"

"That is indeed strange. I should have thought," replied Louisa, "that the higher the weight was placed above the point of support, the more readily would the line of direction have been thrown beyond the base."

"In that respect you are perfectly right; but the balancer will be able to restore it more easily in one case than in the other; since, for reasons which you will presently discover, the greater the circle which a body describes in falling, the less will be its tendency to fall. Look at the sketch which I have prepared for the explanation of this fact, and I think you will readily comprehend the reason of it.



"When the weight is at a considerable distance from the point of support, its centre of gravity, in deviating either on one side or the other from a perpendicular direction, describes a larger circle, as at *a*, than when the weight is very near to the centre of rotation or the point of support, as at *b*. But, in a large circle, an arc of any determinate extent, such as an inch, for example, describes a curve which deviates much less from the perpendicular than if the circle were less; as may be seen by comparing the positions of the sword at *d* and *e*: and the sword at *d* will not have so great a tendency to deviate farther from the perpendicular, as that at *e*; for its tendency to deviate altogether from the perpendicular is greater, according as the tangent to that point of the arc, where it happens to be, approaches more to the vertical position.

You see then that it is less difficult to balance a tall, than a shorter pole; and it is for the same reason that a person can walk with greater security on high, than on low stilts."

"That is very clear," said Louisa, "although, before your explanation, I always associated the idea of difficulty with their height."

"I suppose," added Tom, "that the whole art of walking on stilts may be explained by the principles you have taught us."

"Undoubtedly it may; for the equilibrium is preserved by varying the position of the body, and thus keeping the centre of gravity within the base."

"It must be a great exertion," observed Louisa.

"Before custom has rendered it familiar; after which, there is no more fatigue in walking on stilts, than in walking on our feet. There is a district in the south of France, called the Desert of Landes, which runs along the sea coast between the mouths of the Adour and Gironde, where all the shepherds are mounted on stilts; on which they move with perfect freedom, and astonishing rapidity; and so easily does habit enable them to preserve their balance, that they run, jump, stoop, and even dance, with ease and security."

"How very odd," said Tom; "what can be their motive for such a strange habit?"

"Its objects," replied his father, "are important: to keep the feet out of the water, which, during the winter, is deep on the sands; and to defend them from the heated sand during the summer; in addition to which, the sphere of vision over so perfect a flat is materially increased by the elevation, and the shepherds are thus enabled to see their flocks at a much greater distance. They cannot, however, stand perfectly still upon their stilts, without the aid of a long staff, which they always carry in their hands; this guards them against any accidental trip, and when they wish to be at rest, forms a third leg that keeps them steady."

"I suppose," said Louisa, "that the habit of using these stilts is acquired while they are very young."

"It is, my dear; and it appears that the smaller the boy is, the higher are his stilts; a fact which affords a practical proof of the truth of what I have just stated."

"The stork is said, in my work on Natural History, to be always walking on stilts," said Louisa; "and yet it does not appear to fatigue him."

"That is very true," replied the father; "but you must remember, that nature has furnished the bird with a provision, by which the legs are kept extended without any exertion of the muscles, in the manner of certain springs; a structure which enables it to pass whole days and nights on one foot, without the slightest fatigue."

"But, papa," said Tom, "I have yet some more questions to ask you on the subject of balancing. I am not at all satisfied about many of the tricks that we saw last year; indeed, I cannot believe, that many of those astonishing feats can be explained by the rules you have just given us."

"I very well know to what you allude," replied Mr. Seymour. "Many singular deceptions are certainly practised by removing the centre of gravity from its natural into an artificial situation, or by disguising its place; thus, a cylinder placed upon an inclined surface may be made to run *up*, instead of *down* hill. I can even appear to balance a pailful of water on the slender stem of a tobacco-pipe: but I shall be enabled to explain the nature of these deceptions by some toys which I have provided for your amusement, and which I must say you are fully entitled to possess, as a reward for the clear and satisfactory manner in which you have this day answered my questions. But see! here comes Mr. Twaddleton; he would really seem to possess an instinct that always brings him to the lodge whenever I am preparing some amusement for you."

The vicar smiled as he entered the room, but unwilling to interrupt the lesson, he placed his fore finger on his lip, and with a significant nod, silently took a seat at the table. The children laughed aloud at this cautious demeanour; and Tom exclaimed, "Why, Mr. Twaddleton, our lesson is over, and we are going to receive some new toys as a reward."

"I have here," said Mr. Seymour, as he opened a large wooden box, "a collection of figures, which will always raise themselves upright, and preserve the erect position; or regain it, whenever it may have been disturbed."

He then arranged these figures in battalion on the table, and striking them flat by drawing a rod over them, they immediately started up again, as soon as it was removed. "These figures," continued he, "were bought at Paris some years ago, under the title of *Prussians*."

"I declare," exclaimed the vicar, "they remind me of the rebellious spirits whom Milton represents as saying that ascent is their natural, and descent their unnatural motion."*

"I have seen skreens similarly constructed," said Mrs. Seymour, "which always rose up, of themselves, upon the removal of the force that had pressed them down."

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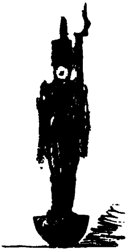
* The vicar here alludes to the speech of Moloch, (Paradise Lost, b. ii. l. 75):—

> "That in our proper motion we ascend
> Up to our native seat: descent and fall
> To us is adverse."

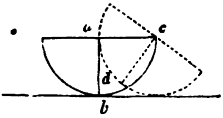
"I will explain their principle," said Mr. Seymour.

"Suppose we first examine the construction of the figure," observed the vicar. "Bless me! why it is like Philotus the poet, who was so thin and light, that lead was fastened to his shoes to prevent his being blown away."



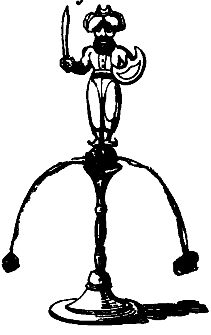
"The figure," said Mr. Seymour, "is made of the pith of the elder-tree, which is extremely light, and is affixed to the half of a leaden bullet; on account, therefore, of the disproportion between the weight of the figure and that of its base, we may exclude the consideration of the former, and confine our attention to the latter. The centre of gravity of the hemispherical base is, of course, in its axis; and therefore tends to approach the horizontal plane as much as possible, and this can never be accomplished, until the axis becomes perpendicular to the horizon. Whenever the curved surface is in any other position, the centre of gravity is not in the lowest place to which it can descend, as may be seen by the diagram which I have just sketched. If the axis *a b* be removed to *c d*, it is evident that the centre of gravity will be raised, and that, if left alone, it would immediately descend again into its original position."

*Fig.* 14.



"I understand it perfectly," said Tom. "When the axis *a b* is perpendicular, the centre of gravity will be in its lowest point, or as near the earth as it can place itself; when, therefore, the figure is pressed down, the centre of gravity is raised, and, consequently, on the removal of that pressure, it will descend to its original position, and thus raise the figure."

"I see you understand it. Here, then," continued Mr. Seymour, "is another toy in further illustration of our subject. It consists of a small figure, supported on a stand by a ball, which is quite loose; and yet it is made to turn and balance itself in all directions, always recovering its erect position, when the force applied to it is removed. The two weights, in this case, bring the centre of gravity considerably *below* the point of suspension or support, and therefore maintain the figure upright, and make it resume its perpendicular position, after it has been inclined to either side; for the centre of gravity cannot place itself as low as possible, without making the figure stand erect."

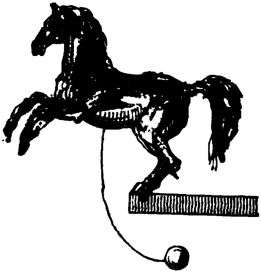


"That is very evident," cried Louisa.

"I shall next exhibit to you," continued Mr. Seymour, "a toy that furnishes a very good solution of a popular paradox in mechanics; viz. *A body having a tendency to fall by its own weight, how to prevent it from falling, by adding to it a weight on the same side on which it tends to fall.*"

"That is indeed a paradox!" exclaimed Louisa. "The next time I see the gardener sinking under the load of a heavy sack, I shall desire him to lighten his burden by doubling its weight."

"Will you, indeed, Miss pert? I do not think so, after you have seen the operation of the toy I am now about to exhibit. Here, you perceive, is a horse, the centre of gravity of which would be somewhere about the middle of its body; it is, therefore, very evident that, if I were to place its hinder legs on the edge of the table, the line of *direction* would fall considerably beyond the base, and the horse must be precipitated to the ground; you will, however, perceive that there is a stiff wire attached to a weight which is connected with the body of the horse, and by means of such an addition, the horse prances with perfect security at the edge of the precipice: so that the figure which was incapable of supporting itself is actually prevented from falling, by adding a weight to its unsupported end!"



The children admitted the truth of this statement, and were not immediately prepared to explain it.

"The weight, indeed, appears to be added on that side; but, in reality, it is on the opposite side," said the vicar.

"In order to produce the desired effect," observed Mr. Seymour, "the wire must be bent, so as to throw the weight far back, under the table; by which contrivance, since the centre of gravity of the whole compound figure is thrown into the leaden weight, the hind legs of the horse thus become the point of suspension, on which the ball may be made to vibrate with perfect security."

"Now I understand it," cried Tom; "instead of the weight supporting the horse, the horse supports the weight."

"Exactly so. You perceive, therefore, from these few examples, that the balancer, by availing himself of such deceptions, and combining with them a considerable degree of manual dexterity, may perform feats, which, at first sight, will appear in direct opposition to the laws of gravity. There is also another expedient, of which the balancer avails himself, to increase the wonder of his performances, and that is the influence of rotatory motion, which, you will presently see, may be made to counteract the force of gravity."

"I remember that the most surprising of all the tricks I witnessed was one, in which a sword was suspended on a key, which turned round on the end of a tobacco-pipe; on the top of the sword a pewter-plate was, at the same time, made to revolve with great velocity."

"I well remember the trick to which you allude. The rotatory motion prevented the sword from falling, just as you will hereafter find the spinning of the top will preserve it in an erect position. There is also another effect produced by rotatory motion, with which it is essential that you should become acquainted. You, no doubt, remember that momentum, or the velocity of a body, will compensate for its want of matter. A number of bodies, therefore, although incapable of balancing each other, when in a state of rest, may be made to do so, by imparting to them different degrees of motion. I believe that you are now acquainted with all the principles upon which the art of balancing depends; and I have little doubt, should we again witness a performance of this kind, that you will be able to explain the tricks, which formerly appeared to you so miraculous."

# CHAPTER V.

THE CHINESE TUMBLERS, ILLUSTRATING THE JOINT EFFECTS OF CHANGE IN THE CENTRE OF GRAVITY OF A BODY, AND OF MOMENTUM. — MR. TWADDLETON'S ARRIVAL AFTER A SERIES OF ADVENTURES.—THE DANCING BALLS.—THE PEA-SHOOTER.—A FIGURE THAT DANCES ON A FOUNTAIN. — THE FLYING WITCH. — ELASTICITY. — SPRINGS. — THE GAME OF "RICOCHET," OR DUCK AND DRAKE. — THE REBOUNDING BALL.—ANIMALS THAT LEAP BY MEANS OF AN ELASTIC APPARATUS.—A NEW SPECIES OF PUFFING, BY WHICH THE VICAR IS MADE TO CHANGE COUNTENANCE.

EARLY on Monday morning did the young group assemble in the library; they had been told by Mrs. Seymour that their father had received a new toy of a very interesting and instructive nature, and we can easily imagine the eagerness with which they anticipated the sight of it.

"I trust," said Mr. Seymour, "that after our late discussion, the subject of the centre of gravity is thoroughly understood by you all. I have also reason to think that the nature and effects of what is termed *momentum* have been rendered intelligible to you."

"I certainly understand both those subjects," answered Tom; and so thought the rest of the party.

"Well, then, I will put your knowledge to the test," observed Mr. Seymour, "for you shall explain to me the mechanism of these *Chinese Tumblers.*" Upon which he produced an oblong box, which, by opening, formed a series of stairs or steps, and took from a drawer at its end two grotesque figures (*Clown* and *Pantaloon*), which were connected with each other by two poles, which they appeared in the attitude of carrying, pretty much in the way that the porters carry the poles of a sedan-chair. The foremost figure was then placed upon the top step, when, to the great astonishment of the whole party, the figures very deliberately descended the several stairs, each turning over the other in succession.

"There was a period in our history," observed Mrs. Seymour, "when so marvellous an exhibition would have subjected the inventor to the penalties of sorcery."

"That," remarked Mr. Seymour, "may be said of most of the other inventions which I have yet in store to illustrate the powers conferred upon us by a knowledge of natural philosophy; but as far as mechanical skill is concerned, I doubt whether the ancients did not even surpass us, especially in the art of constructing automata; and as quicksilver was known in the remotest ages, I think it not improbable that it was one of the agents employed by them on such occasions. If I remember right, Aristotle describes a wooden Venus, which moved by means of '*liquid silver;*' then again, the moving tripods which Apollonius saw in the Indian temples

—the walking statues at Antium, and in the temple of Hierapolis, and the wooden pigeon of Archytas,* ought, undoubtedly, to be regarded as evidences of their mechanical resources. But let us reserve these literary questions for the better judgment of our worthy friend the vicar, and proceed to consider the mechanism of the toy before us. Tom," continued he, "take the figures in your hand and examine them."

No sooner had the young philosopher received the figures from the hand of his father than he declared that the tubes were hollow, and that he felt some liquid running backwards and forwards in them.

"You are quite right, my boy," said Mr. Seymour, "they contain quicksilver."

"Now then I understand it," cried Tom; "the quicksilver runs down the tubes and alters the centre of gravity of the figures, and so makes them tumble over each other."

"Well, I acknowledge that is no bad guess as a beginning, and will certainly explain the first movement; but you will be pleased to recollect that the instant a new centre of gravity is thus produced the figures must remain at rest—how, then, will you explain their continued motion?"

"You said something, I think, about momentum; did you not, papa?"

"Certainly; and to its agency the continuance of the motions is to be ascribed: but I will explain the operation more fully."

Mr. Seymour then proceeded to point out the mechanism and movements of the toy in a manner which we shall endeavour to convey to our readers by the aid of the annexed engraving.

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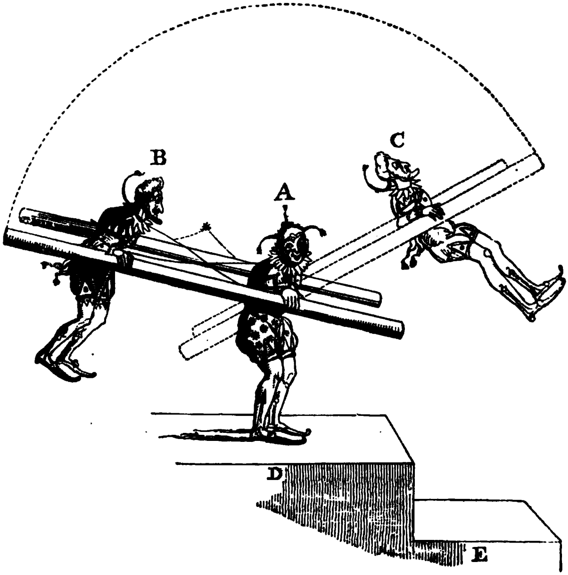
* Upon this subject, Dr. Brewster's Introductory Letter on Natural Magic will be read with interest and advantage.



As soon as the figure A is placed upon the step D, in the position A B, the quicksilver, by running down the inclined tubes, swings the figure B round to C; and the centre of gravity having been thus adjusted, the whole would remain at rest but for the contrivance to be next described. Besides their connexion with the poles by means of pivots, the figures are connected with each other by silken strings, which keep the figure B steadily in its position, while it traverses the arc until it arrives at C, when their increased tension has the effect of capsizing it, and of thus producing a momentum, which, by carrying its centre of gravity beyond the line of direction, causes it to descend upon the step

E, when the quicksilver, by again flowing to the lowest part of the tubes, places the figures in the same position, only one step lower, as they were at the commencement of their action; and thus, by successive repetitions of the same changes, it is quite evident that the figures must continue to descend as long as any steps remain for their reception."

"I understand it perfectly," observed Louisa, with a smile of satisfaction.

"I need scarcely say," continued Mr. Seymour, "that there are some niceties in the adjustment of the minuter parts of the apparatus, without which the effect could not be accomplished; the quantity of quicksilver, for instance, must bear its proper proportion to the weight and dimensions of the figure: and in order to prevent its too rapid passage along the inclined tubes, strings are stretched across their interior to retard the stream. Then, again, some management is necessary with regard to the silken strings, in order to ensure a necessary degree of tension. I will now show you," said he, "a single tumbler, which will perform the same motions without the assistance of any tubes."

"But not without quicksilver," observed Tom, "which, I suppose, must, in this case, be put into the body of the figure."

"You are quite right; and it is made to pass from one extremity of its body to the other through a small orifice, which has the same effect as the strings in the tubes, in breaking the current and preventing its too rapid motion. In all other respects, the principle is the same as in the double figures."

Just as Mr. Seymour had terminated his exhibition of '*Le petit Culbuteur*,' the welcome appearance of the vicar infused fresh spirits into the little party.

"My dear friends," said Mr. Twaddleton, "I have been most provokingly detained by that tiresome etymologist Jeffrey Prybabel. I made many efforts to escape, but I was as a fly in a cobweb."

"He is the greatest bore in all Christendom; I knew him well," observed Mr. Seymour, "when he practised as a Conveyancer in Gray's-Inn, and went by the nickname of the Riot Act; for in such horror was he held that, if a number of persons were congregated, his approach was sure to disperse them. But what has been the subject of your discourse?—was the etymologist merely airing his vocabulary, or did he propose some difficult question for discussion? Be this, however, as it may, I will venture to say that he was, as usual, loquacious on the subject of *mutes*—dry on the use of *liquids*, and descanting without end on the importance of a *termination?*"

"Mr. Seymour, I am really and truly ashamed of you; punning, under any circumstances, is a most disgraceful habit, but when employed to distort the meaning of language it becomes absolutely criminal."

To turn the subject of this discourse, the vicar proceeded to inform Mr. Seymour that he had no sooner escaped from the fangs of Prybabel than he encountered *Polyphemus*. Our readers may, perhaps, wonder who this *Polyphemus* could have been; we must, therefore, inform them that Mr. Twaddleton, whose ideas were always tinctured with classical colouring, had bestowed this appellation upon the renowned Dr. Doseall, the Esculapius of Overton, because, as he said, his practice was like the Cyclops, *strong but blind;* and Mr. Seymour declared that the similitude was even more perfect than the vicar had contemplated, for he observed that he certainly fattened upon the unhappy victims who fell within his clutches.

With all our respect for the liberality of Mr. Seymour and the kind-heartedness of the vicar, we must, in justice to this respectable son of Apollo, express our disapprobation at so provoked a sarcasm. We acknowledge that Dr. Doseall, by the aid of low bows and high charges—of little ailments and large potions, had contrived to secure a very comfortable balance on the creditor side of his worldly ledger. We also admit, that, after the example of other celebrated physicians, he had one sovereign remedy, which he administered in every disease. But what of that? he was often successful in his cures—that is to say, his patients sometimes recovered *after* they had taken his physic; and is not that the test conventionally received in proof of the skill or ignorance of greater physicians than Dr. Doseall? Nor can we persuade ourselves into the belief, that a doctor who faithfully adheres to one single remedy, is less likely to be right than those restless spirits who are eternally coquetting with all the preparations of the Pharmacopœia without ever remaining steady to any one of them. It has been truly remarked, that the clock which stands still and points steadfastly in one direction, is certain of being right twice in the twenty-four hours, while others may keep going continually, and as continually going wrong. Being ourselves no doctors, we merely throw out this hint for the consideration of those who are learned in such matters: but we beg pardon of our readers for this digression.

"Well," said Mr. Seymour, "I am, at all events, rejoiced to see our Trojan in safety, after such perilous adventures; and I hope that he is now prepared to set sail again with us, on a new voyage of discovery. I have been engaged," continued he, "in explaining still farther the nature of momentum, and I now propose to exhibit an experiment of a different kind, in order to illustrate the same subject. You, no doubt, remember," continued Mr. Seymour, "that velocity makes up for weight: although, therefore, a fluid, as air, or water, may, in a state of quiescence, be unable to support a body, yet, by giving it a certain velocity, it may acquire a sustaining power. I have here several gilded pith-balls, through one of which I have run two pins, at right angles to each other: the naked points, you perceive, are defended with sealing-wax, to prevent any mischief that might arise from their accidentally coming into contact with your face. By means of this brass tube, (the stem of a tobacco-pipe will answer the same purpose,) I shall produce a current of air by my breath, and you will observe that the little ball will continue to dance, as if unsupported."

Mr. Seymour then placed the pith-ball at the end of the pipe, and, inserting its other extremity in his mouth, blew out the ball, which immediately rose in the air, and continued to float about for several seconds: he then drew in his breath, and caught it with much address on one of its points; and in this manner, alternately floating and catching it, did he continue to delight the wondering group for several minutes.

Tom received the tube and ball from the hand of his father, and soon succeeded in playing with it. Observe, gentle reader, the address with which the boy manages it.

"This reminds me of my pea-shooter," said Tom, as he removed the tube from his mouth, "with which I have often shot a pea across the play-ground."

"Exactly; and you will now understand the nature of the force by which your pea was projected. The air blown from the lungs, gains such momentum from the contracted channel in which it flows, as to impart considerable velocity to the pea placed within the influence of its current."

Mrs. Seymour observed, that she had lately read in Waterton's "Wanderings in South America," a very interesting account of the Indian blow-pipe, which the natives of Guiana employ as an engine for projecting their poisoned arrows, and which owes its power to the principle of which Mr. Seymour had just spoken, and its unerring accuracy to the skilful address of the Indian who uses it. (10)

"Mr. Seymour," said the vicar, "I much like your experiment with the pith-balls; but do tell me the use of the pins that are passed through them."

"They are not absolutely necessary for the success of the experiment: indeed, I ought to have stated, that their only use is to ensure the elevation of the ball to a certain distance above the orifice of the tube, before it is set adrift."

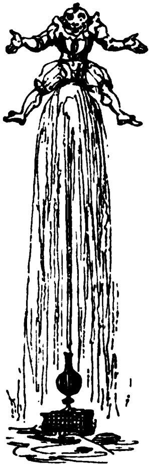
"'*Ne turbata volent rapidis ludibria ventis*,' as Virgil has it. I duly appreciate the contrivance; but if the ball was set off at a distance from the orifice, such an expedient would be unnecessary."

"Certainly," answered Mr. Seymour; "I will soon convince you that, under the condition you propose, the pins are not essential."

So saying, he placed the tube in his mouth, and by carefully holding the ball at a distance of about half an inch from its orifice, he was enabled to consign it at once to a continuous and steady stream of air, which can never be commanded at the point from which the air issues; and he thus succeeded in sustaining the ball in motion, in the same manner as he did in the preceding experiment.

"We will now proceed to the orchard," said Mr. Seymour, "where I have prepared another pleasing exhibition of a similar description."

The party accordingly left the lodge, and when they had arrived at the fountain, their father produced a small wooden figure, of which the annexed is a sketch. Within its base was fixed a hollow sphere, or ball of thin copper, which, when properly adjusted on a fountain, or *jet d'eau*, was sustained by the momentum produced by the velocity of the stream; so that the whole figure was balanced, and made to dance on the fountain, as the pith-ball had been made to play in the current of air.



The children were much gratified at witnessing so curious an exhibition. Mr. Twaddleton laughed heartily at the ludicrous effect it produced, and observed that, although he had never before seen the experiment, he had frequently heard of it; and he added, that he understood it to be a very common toy in Germany and Holland.

"I have for some time," said Mrs. Seymour, "been trying to construct a light figure of this kind, which shall dance on a current of air; and I believe I have at length succeeded. The head I have formed of the seed vessel of the *Antirrhinum*, which has a striking resemblance to a face, and possesses, moreover, the indispensable condition of lightness. The dress is made of silver paper, stretched over a cone of the same material. From its appearance I have named it the *Flying Witch*."

"I admire your ingenuity," said Mr. Seymour, "and I have no reason to doubt the success of your enterprise."

"I found it convenient," continued Mrs. Seymour, "to place a stage of card below the orifice of the tube, in order to steady the figure as she rises, and to receive her as she falls."

"Your principal care," observed her husband, "must be to throw the centre of gravity of the figure as low as possible."

On the party returning to the library, Mr. Seymour expressed a wish that, before they suspended their morning's recreations, they should take into consideration a peculiar property of matter, which they had not yet discussed.

"And what may that be?" asked Louisa.

"ELASTICITY," replied her father; "and I wish to hear whether Tom can explain to us the meaning of the term."

Tom very well knew what was meant by Elasticity; but he was like many a merchant with a bill of exchange, who, although well acquainted with its value, has not sufficient small change to cash it. Tom wanted words to enable him to furnish a clear definition; his father, therefore, kindly relieved his embarrassment, by informing him that "it was a property inherent in certain bodies, by which they possessed a disposition to have their form altered by force or pressure, and to recover it on the removal of that pressure, throwing off the striking body with some degree of force; for example," continued he, "the cane which I hold in my hand can be bent to a certain extent, and then, if I let it go, it will immediately return to its former condition with considerable force."

Louisa inquired whether bending and pressing upon a body were the same thing. Mr. Seymour replied that the form of an elastic body might be altered either by compression or distension, and that *bending* was, in fact, only a combination of these two methods; "For," said he, "when a straight body, like my cane, is bent, those particles of it which are on the one side are compressed, while those on the other are distended. But let us proceed with the subject. I have said that elastic bodies, on returning to their original form, throw off the striking body with some degree of force. I have here," continued Mr. Seymour, taking out of his pocket a wooden image of a cat, "a toy which I intend as a gift to John; it will serve to illustrate our subject. The tail, you perceive, is movable, one of its ends being tied to a piece of catgut, which is a highly elastic substance. When I bend the tail under the body of the animal, I necessarily twist the string; and by pressing the other end of the wooden tail upon a piece of wax, I can retain it for a few seconds in that situation."

Mr. Seymour having fixed the tail in the manner above described, placed the wooden image on the ground, when, in a few seconds, it suddenly sprang forward, to the great delight of the younger children.

"Can you explain this action?" asked Mr. Seymour.

"The wax," answered Tom, "was incapable of holding the end of the tail longer than a few seconds; and as soon as it was let loose, the elasticity of the catgut enabled it to return to its former condition; in doing which the tail struck with force against the ground, which threw off the body of the cat and produced the leap."

"Very well explained; and you, no doubt, will readily perceive that the operation of steel springs depends upon the same principle of elasticity: a piece of wire or steel, coiled up, may be made to set a machine in motion by the endeavour it makes to unbend itself. This is the principle of the spring in a watch. When our watches are what is termed *down*, this steel has uncoiled itself; and the operation of winding them up, is nothing more than that of bending it again for action. (11) If the elasticity of a body be *perfect*," added Mr. Seymour, "it will restore itself with a force equal to that with which it was compressed. As I have given John a toy, it is but fair that I should reward you, Tom: open that box, and examine the gift which it contains."

Tom received the present from his father, and proceeded to open the lid, when, to his great astonishment, the figure of an old witch suddenly sprang upwards. Mr. Seymour explained its mechanism, by stating "that the figure contained a wire coiled up like a corkscrew, and which, upon the removal of the pressure of the lid which confined it, immediately regained its original form." (12)

Tom inquired what kind of bodies was most elastic. He was informed that the air was the most elastic of all known substances, and had, for that reason, been distinguished by the name of an *elastic* fluid. Hard bodies were so in the next degree; while soft substances which easily retain impressions, such as clay, wax, &c. might be considered as possessing but little elasticity.

"I should have thought," said Louisa, "that neither clay nor wax had possessed *any* elasticity."

"My love, we know not any bodies that are absolutely, or perfectly, either hard, soft, or elastic; since all partake of these properties, more or less, in some intermediate degree. Liquids are certainly the least elastic of all bodies; and, until lately, water was regarded as being perfectly inelastic; but recent experiments have shown it capable of compression, and of restoring itself to its original bulk, as soon as the pressure is removed; it must, therefore, possess some elasticity. Indeed," said Mr. Seymour, "we might have anticipated such a result from the effects which present themselves in the well-known game of '*Ricochet*,' or *Duck and Drake*."

"*Duck and Drake!*" exclaimed Louisa; "for goodness' sake, what can that game be?"

"I dare say your brother will not have any difficulty in explaining it to you."

Tom informed her that it was a game in which any number of boys threw a stone, or a flat piece of tile, into the water; and that he whose stone rebounded the greatest number of times was the conqueror.

"It is a very ancient game," said Mr. Seymour, "and had the vicar been present, we should have heard a learned disquisition upon it; as he, however, is unfortunately absent, I must tell you all I know upon the subject. It was called by the Greeks *Epostrakismos*,* and was anciently played with flat shells. Now it is evident that the water must possess some degree of elasticity, or the stone could not rebound (13); but I shall have occasion to revert to the subject hereafter."

"And are my marbles elastic?" asked Tom.

"Undoubtedly; but not to the same extent as your ball. There," said Mr. Seymour, throwing his ball against the wall, "see how it rebounds."

"The return of the ball," observed Tom, "was, I suppose, owing to its elasticity; and I now understand why one filled with air rebounds so much better than one stuffed with bran or wool."

"You are quite right; and the return of the ball, after having struck the wall, affords an example of what is termed *reflected* motion, upon which I shall have to remark when we come to the interesting subject of 'Compound Forces;' but at present, my only wish is to render the property of elasticity intelligible to you. It is a force of very extensive application; there is scarcely a machine wherein the elasticity of one or more solids is not essentially concerned. Nature, also, avails herself of this property to accomplish many of her purposes. Fleas and locusts are enabled to jump two hundred times the height of their own bodies by means of a springy membrane, easily visible by a microscope; so that, supposing the same relative force to be infused into the body of a man six feet high, he would be enabled to leap three times the height of St. Paul's: and the regular dispersion and sowing of the seeds of several plants is effected by a spring, which is wound sometimes round the outside, and at others, round the inside, of the case in which the seeds are contained." (14)

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* Pollux, lib. ix. c. 7.

"I suppose," said Tom, "that it is by some such spring shrimps are enabled to leap the tops of cataracts, as I have read in my work on Natural History."

"Many species of fish are thus enabled to leap, by bending their bodies strongly, and then suddenly unbending them with an elastic spring; and the long-tailed crayfish, and the common shrimp, leap by extending their tails, after they have been bent under their bodies."

"We will now conclude our diversions," said Mr. Seymour, "with an exhibition of a very striking description. Here," cried he, as he removed a small piece of apparatus from a box which stood on the table, "is a toy, at which the sternest philosopher, nay, even Heraclitus, of weeping memory, could not refrain from laughing."

He then displayed a small ball of Indian rubber, on which was painted an exact resemblance of the worthy vicar, executed under the direction of Mr. Seymour, by that inimitable artist, George Cruikshank. The ball was connected with an air syringe, by which it was easily distended. It gradually increased in magnitude, swelling, like the gourd of Jonas, as the inflation proceeded, and the countenance of the vicar progressively enlarged to the size of the full moon, without the least alteration in the character or expression of its features."

"I declare," said Mr. Seymour, "the vicar *improves upon acquaintance*."

"It must be acknowledged that you have *puffed* him into consequence," observed Mrs. Seymour.

The countenance had, after a short time, swelled to ten times its original dimensions: the children deafened Mr. Seymour with their shouts, and the good-humoured clergyman was actually convulsed with laughter. The stop-cock was now turned; the elastic bladder became smaller and smaller, and the features underwent a corresponding diminution, until they once again assumed their original dimensions.

"You perceive, my dear Sir, that I make you *look small* again."

"That is by no means an unusual effect of your jokes," replied the vicar.

"Now, Tom," said his father, "it is for you to explain the nature of the exhibition you have just witnessed."

Tom proceeded accordingly.

"The bladder was highly elastic, and therefore readily yielded to the pressure of the air, and became distended. As soon, however, as the pressure was removed, the air was driven out again with force, and the particles of the Indian rubber returned to their former condition. But I observed one circumstance which I do not understand," said Tom: "when you first turned the stop-cock, the air rushed out with great violence, and the ball diminished very rapidly: but it gradually slackened, until, at last, the bladder could scarcely be seen to contract."

"I rejoice to find that you were so observant," said his father: "the effect you noticed depended upon a general law of elasticity. Elastic bodies, in the recovery of their forms from a state of compression, after the removal of the compressing force, exert a greater power at first than at last, so that the whole progress of restoration is a *retarded* motion."

The vicar, who had listened with profound attention to the explanation which the boy had offered, rushed forward at its conclusion, and clasping him in his arms, declared, that a first-class man of Trinity could not have succeeded better.

"But let us now, if you please, Mr. Seymour, suspend our researches: recollect," said the vicar, "that your birds are, as yet, scarcely fledged; and they will, therefore, make greater advances by short flights frequently repeated, than by uninterrupted progression."

We heartily concur in this opinion, and shall, therefore, terminate the chapter.

## CHAPTER VI.

THE ARRIVAL OF MAJOR SNAPWELL, AND THE BUSTLE IT OCCASIONED. — THE VICAR'S INTERVIEW WITH THE STRANGER. — A CURIOUS DISCUSSION. — A WORD OR TWO ADDRESSED TO FOX-HUNTERS. — VERBAL CORRUPTIONS. — SOME GEOMETRICAL DEFINITIONS. — AN ENIGMA.

As the ladies of Overton were regaling themselves with a sociable dish of tea and chat, the conversation was abruptly interrupted by the appearance of a chariot-and-four, that passed along the road with luxurious speed, and which, as Miss Kitty Ryland declared, announced, by the dignified suavity of its roll, that the personage it conveyed must be of superior rank.

"Those," exclaimed she, "who cannot at once distinguish such 'spirit-stirring' sounds from the discordant rattle of a plebeian chaise, deserve to wear the ears of Midas."

This extraordinary subtlety of Miss Ryland's ears is said to have been conferred upon them by those universal promoters of bodily vigour, *air* and *exercise*, of which they had received the combined advantage by the ingenious habit of listening to whispers through a certain pneumatic apparatus, familiarly termed a *keyhole*. In farther proof of the fidelity and alertness of her auditory establishment, we may just state, that, on passing Doseall's shop, she never failed to distinguish, by the sound of the mortar, whether the medicines under preparation were designed for the stomachs of the rich or the poor. The vicar even admitted the correctness of her discrimination, for he had himself observed that the pestle beat *dactyls* in one case, and *spondees* in the other.

While the carriage was passing the window, the maiden companions were breathless with wonder, each catching a glance from the countenance of her neighbour, which heightened, as it were by reflection, the surprise depicted on her own.

"Overton," exclaimed Miss Noodleton, "is doubtless by this time honoured by the arrival of some distinguished stranger; but who he is, or what may be the object of his visit, I am at a loss to divine."

"Pooh!" cried Miss Puttle; "what a fuss is here about a green carriage and four hack horses! I doubt not but that it has conveyed some visitor to the vicar: had the Seymours expected any company, I must have heard of it yesterday."

"To the vicar!" exclaimed Miss Phillis Tapps; "and pray, Miss Puttle, allow me to ask whether you ever heard of the peacock nestling with the crow?"

"Or of the eagle taking up its abode in an ivy-bush?" vociferated Miss Ryland.

Conjectures were vain, and the party determined to resolve itself into a committee of inquiry. In the first place, it was judged expedient to see and question Ralph Spindle, whom Dr. Doseall employed on the arrival of a stranger, as certain insects are said to use their '*feelers*' to discover the approach of any prey that may serve them as food.

The stranger was soon discovered to be a Major Snapwell, a rich and eccentric old bachelor, who had served in various campaigns in different parts of the globe, and received a competent number of wounds, in the defence of his king and country. His income was reported to be large, and it was said, that he had not any near relative to enjoy the reversion, since his nephew had perished about two years before by shipwreck. The circumstances that led to this disastrous event were believed to have so affected the veteran, as to have occasioned a very serious illness, and a consequent state of despondency, for which his physicians advised a constant change of scene; so that he had been rambling about the Continent during the last year and a half, accompanied only by his faithful servant, Jacob Watson, who was as much attached to the Major, as was ever a Newfoundland dog to his master.

Such was the information derived from Annette, the vicar's housekeeper: what proportion of fiction was mingled with its truth, the reader will probably soon be able to discover.

"Well, Jacob," said the Major, as his trusty but asthmatic valet was leisurely buttoning on the long gaiters of his master the morning after his arrival, "what do you hear about this village of Overton? Are there any sociable neighbours? I like the country; it is beautiful, Jacob, and the air appears mild: it promises to be the very place to kindle the sparks of my expiring constitution; and should you, at the same time, get your broken-winded bellows mended, my vital flame might, perhaps, burn a little brighter. But tell me, what do you hear of it, Jacob?"

"Why, and please you, Major, I just now met an old crony of mine, Mrs. Annette Brown, at the Devil and the Bag of Nails——"

"And pray, Jacob," exclaimed the Major, "who taught you to speak thus irreverently of the village blacksmith?"

"The village blacksmith! Lord love you, it is the sign of the village alehouse!"

"Then it is a very odd one; but go on with your story."

"As I was saying, Major, I met an old acquaintance who is housekeeper to Mr. Twaddleton, a bachelor gentleman, and the vicar of the parish. She tells me her master is downright adored in the place: though he must needs be a queer mortal, for she says he is so fond of *antics* that he won't suffer a mop or broom in his house, lest, I suppose, it should spoil the hopping of the fleas, and put an end to the fly's rope-dance upon a cobweb."

"Jacob, Jacob, you are a wag, and had better go and offer your services to this merry parson, although, I fear, your asthmatic pipes would prove but a sorry accompaniment to his capering. But pshaw!—fiddlestick!—stuff and nonsense!—who ever heard of a vicar being fond of antics?—you are imposed upon, Jacob."

"I am sure that how Annette told me as much. Ay, and she said he had all sorts of *curosities* in his parlour—such as grinning faces, dogs with three heads, rusty swords, and I do not know what besides."

"I see it!—see it all plainly!" exclaimed the Major; "and your story has so delighted me that I could almost dance myself." This respectable clergyman, thought he, is, doubtless, an antiquary, a virtuoso—what a delightful companion will he prove! And a bachelor like myself!—what *tête-à-têtes* do I anticipate!

"Jacob," exclaimed the Major, "you should have said that the vicar was fond of, or, to speak more correctly, devoted to *antiques*, not to *antics*. But, tell me whether there are any other agreeable persons in this village?"

"There's the squire and his family," answered the valet.

"The name, the name, Jacob?"

"Squire Seymour, and please you, Major."

"Seymour, Seymour!" repeated the Major; "I seem to know that name—let me remember."

The Major's cogitations, however, were abruptly cut short by the entrance of the servant-maid, who informed him that Mr. Vicar Twaddleton had called.

"I beg that Mr. Twaddleton may be admitted. —Jacob, place a chair."

"Mr. Twaddleton," said the Major, as he advanced towards the door to meet his visitor, "I feel obliged and honoured by your kind attention. As a perfect stranger, I could scarcely have expected this civility; but your village, surrounded as it is with all the softer charms of Nature, is calculated to impress the hearts of its inhabitants with a kindred amenity. The inhabitants are, doubtless, much attached to their country."

"Proverbially so: never was Ulysses more attached to his Ithaca! Allow me, also, to say that we all rejoice at the arrival of visitors; and as vicar of the parish of Overton, I should consider myself criminally deficient in my duty were I to suffer a respectable stranger to depart from us without his having received the mark of my respect, and the tender of my humble but cordial hospitality. I am an old-fashioned person, Major Snapwell, and am well aware that these antiquated notions do not altogether accord with the cold and studied forms of the present day."

"Mr. Twaddleton," exclaimed the delighted Major, "I thank thee, most heartily thank thee, in the name of all those whose hearts have not yet been benumbed by worldly indifference. Sit thee down—I abhor ceremony—and let me beg of you not to take offence at a question to which I am most anxious you should give me an answer. Are you, my dear Sir, as I have just reasons for supposing, an ANTIQUARY?"

"I am undoubtedly attached to pursuits which might have favoured such a report."

"I thought so; I guessed as much. Then, give me your hand; we must be friends and associates. If there be a pursuit on earth to which I am devotedly attached, it is to that of antiquities; and, let me add, that if there be a literary character to whom the professor of arms ought to feel superior gratitude, it is to the antiquary. How many victories, what valiant deeds, must have perished in the memory of mankind but for the kind offices of the virtuoso! under whose vivifying touch the laurels of the victor have bloomed with renovated vigour! and when the scythe of Time has left them to wither, and to be scattered on the wings of the wind, he collects their remains and piously deposits them in a splendid mausoleum, in order to preserve them to the latest posterity!"

It were difficult to say, whether astonishment at the Major's warmth, delight at the congenial sentiments he had expressed, or admiration at the language in which they had been conveyed, was the feeling predominant in the vicar's mind, nor do we deem it necessary to inquire; suffice it to say, that, from the conversation of a few minutes, these two gentlemen felt incited to a mutual regard by sympathy and congeniality of soul; so true is it that, while we may be strangers with the companions of years, we may become friends with the strangers of yesterday!

"Major Snapwell," said the vicar, "I may truly mark this day in the diary of my life in red letters; your society will add to my happiness, by extending the sphere of my literary intercourse. When may I expect the pleasure of your company at the vicarage? I am really impatient to show you my coins and a few dainty morsels of *virtù.*

"I shall be at your service to-morrow," answered the Major; "but I must now say something about my plans, for it is possible that you may assist me in carrying them into execution."

"Command me," said the vicar.

"For my present purpose, it is only necessary to state, that I have a nephew whom I have adopted as my son; I superintended his education; he arrived at manhood, and became an accomplished scholar and a polished gentleman. Naturally anxious to visit the ancient mistress of the world, he readily obtained my approbation of his plan. He embarked at Marseilles; but meeting with one of those treacherous gales so characteristic of the Mediterranean, he was shipwrecked in the bay of Genoa. For three years did I mourn him as dead, and it was only by a train of circumstances of the most extraordinary description that I at length discovered him to be living. I will not now trouble you with the details of this most singular history; suffice it to say he is now well, and about to be married to a young lady for whom he has long entertained the purest attachment. I am in search of a country residence for them, and hearing that a Sir Thomas Sotherby, a resident, I understand, in your neighbourhood, is most desirous of disposing of Osterley Park, and offers many advantages to any one who will take it off his hands, and as I have both the inclination and the means to become its possessor, I have travelled hither for the purpose of inspecting it. So now you have my history.

"It is perfectly true," said the vicar, "that Sir Thomas is willing to make a considerable sacrifice in order to obtain an immediate purchaser. The health of her Ladyship is in so precarious a state that her physicians have ordered her to proceed, without delay, to Madeira. Sir Thomas, Major, is a fox-hunter, and I will venture to say that no one will miss him but the doctor and the foxes—the one will lose a profitable friend, the other a relentless enemy—'*Gaudet equis et canibus*,' as the poet has it."

"Indeed! but I am no fox-hunter, and I therefore fear that, in the opinion of the country, Osterley Park will not exchange its proprietor to advantage. Pray, vicar, may I ask whether you are addicted to field-sports?"

"Addicted to field-sports!" repeated the reverend antiquary: "I am surprised, mortified, absolutely shocked! I—I addicted to field-sports!"

"Nay, Mr. Twaddleton," observed the Major, "I am really sorry that I should have unintentionally excited your indignation. I am not aware that there is any thing in the innocent pastime to which I have alluded inconsistent with your station or acquirements. As an antiquary, I need hardly remind you that the fathers of the Church were amongst the keenest sportsmen. Do you not remember the amusing portrait which Chaucer has given us of a sporting monastic in the 14th century, and which, by the by, was the model from which Sir Walter Scott drew the character of his Abbot in "Ivanhoe?" Then again, need I call to your recollection the fame of Walter, Archdeacon of Canterbury, who was promoted to the see of Rochester in 1147, and who is said not only to have spent the whole of his time in hunting, but to have been as keen a sportsman at eighty as he was at twenty years of age? Then again, there was Reginald Brian, translated to the see of Worcester in 1352; and William de Clowne, whom his biographer celebrated as the most amiable ecclesiastic that ever filled the abbot's throne of St. Mary in Leicestershire, the most knowing sportsman after a hare in the kingdom; insomuch, indeed, that Richard II. and his son allowed him annual pensions for his instructions in the art?"

"Major Snapwell, antiquity can no more privilege error, than novelty can prejudice truth," exclaimed the vicar: "but, to be serious," continued he, "I never could discover the principle upon which the pleasure of this said diversion of Diana can depend: and yet I do assure you, sir, that I have not failed to submit the question to a logical examination. Thus, for instance:—the fox emits from his body certain odorous particles;—that is my *major*, and I say *concedo:* very well; I proceed. The structure of the olfactory organs of the canine species enables them to perceive this said odour: that is my *minor*, and I say again *concedo*. But I should much like to be informed how any logician can defend the consequence which is deduced from these premises. To speak more syllogistically, why am I pleased to put my neck in jeopardy, *because* my dogs happen to perceive a smell?"

The Major laughed heartily at the very ludicrous point of view in which the worthy vicar had thought proper to represent the subject. Their discourse now took a different turn. The Major inquired what might be the origin of the singular sign of the village inn—*The Devil and the Bag of Nails?* "Satan," continued the Major, "is unquestionably the patron of the public-house; but why he should be represented as holding in his hand a bag of nails, I cannot divine, unless, indeed, in reference to the old adage, that '*Every glass of spirit is a nail in your coffin.*'"

"Ha! ha! ha! whimsical enough," cried the vicar; "but, unfortunately, your explanation is not the true one. The sign," observed Mr. Twaddleton, "is not quite so uncommon as you seem to suppose; it was originally '*Pan and his Bacchanals,*' but, by a very natural transition, the figure of the sylvan deity, which is certainly terrific* enough to sanction the mistake, has passed into that of the evil tempter; while the word *Bacchanals,* by one of those verbal corruptions so common in all languages, has been converted into the *bag of nails.*"

"Very true," said the Major; "whenever the vulgar are incapable of understanding the meaning of a word, they are sure to substitute for it some one which has the nearest resemblance to it in sound, and which is more familiar to them. I had but just now an excellent instance of this kind: my blundering servant Jacob insisted upon it that you were fond of *antics;* and before I left London, on sending him out to purchase a *Court Calendar,* what do you suppose he brought home?—a *Quart Cullender!*"

The vicar was much amused by the absurdity of the mistake.

"I lately heard," continued the Major, "of a Welsh squire, who, upon being questioned whether *Socinianism* or *Arianism* prevailed in his district, replied, that he could not answer that question, but that he knew there had been a great deal of *Rheumatism.*"

But the good company of the major and his newly acquired friend must not detain us any longer from our duty. Mr. Seymour and his young family have re-assembled in the library, and it is necessary that we should immediately join them. Some of our readers may, perhaps, decline accompanying us upon this occasion; for the subject to be discussed, however necessary it may be, is certainly not so entertaining as many of those which have engaged our attention. If this be the case, they may make a short cut, and join us again at the beginning of the following chapter. The children had arranged themselves around the table, when their father observed, that it would be necessary for their future progress, to devote an hour or two to the consideration of several mathematical figures and terms.

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* To the terror-inspiring power of Pan we owe the word "*Panic.*"

"As to mathematical figures," said Tom, "if you allude to squares, circles, and figures of that description, and to parallel lines, angles, and so on, I can assure you that I am already well acquainted with them; for the work you have given us on PAPYRO-PLASTICS* has fully instructed me in those particulars."

"If that be the case," replied Mr. Seymour, "you will not have any difficulty in answering my questions; but we must, nevertheless, go regularly through the subject, for the sake of your sisters, who may not be equally proficient in this elementary part of geometry: tell me, therefore, in the first place, what is meant by a *parallelogram*.

"A four-sided figure," answered Tom.

"That is true; but are there not some other conditions annexed to it?"

"Yes; its opposite sides are parallel."

"And what do you understand by the term *parallel*?"

"Lines are said to be parallel," said Tom, "when they are always at the same distance from each other, and which, therefore, can never meet, though ever so far continued."

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* PAPYRO-PLASTICS," or the Art of modelling in Paper; from the German, by Boileau. *London*, 1825. The Author strongly recommends this interesting little work, as opening a new source of instructive amusement. His own children have derived from it many hours of rational recreation.

"You are quite right. What is a *square?*"

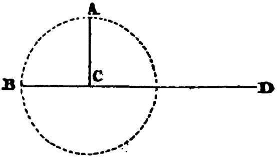
"A four-sided figure, in which the sides are all equal, and its angles all right angles."

"Good again: but let me see whether you have a correct notion of the nature of an angle."

"An angle is the opening formed by two lines meeting in a point."

Mr. Seymour here acknowledged himself perfectly satisfied with his son's answers, and said, that he should accordingly direct his attention more particularly to Louisa and Fanny; and, taking his pencil, he sketched the annexed figure.

*Fig.* 1.



"You perceive, Louisa," said her father, "that the line A C makes two angles with the line B D, viz. the angle A C D and the angle A C B; and you perceive that these two angles are equal to each other."

"How can they be equal?" cried Fanny, "for the lines are of very different lengths."

"An angle, my dear girl, is not measured by the *length* of the lines, but by their *opening.*"

"But surely," said Louisa, "that amounts to the same thing: for the longer the lines are, the greater must be the opening between them."

"Take the pair of compasses," replied her father, "and describe a circle around these angles, making the angular point C its centre."

"To what extent am I to open them?"

"That is quite immaterial; you may draw your circle of any magnitude you please, provided it cuts both the lines of the angles we are about to measure. All circles, of whatever dimensions, are supposed to be divided into 360 parts, called *degrees;* the size, but not the number, of such degrees will therefore increase with the magnitude of the circle. And since the opening of an angle is necessarily a portion of a circle, it must embrace a certain number of degrees; and two angles are, accordingly, said to be equal, when they contain an equal number of them."

"Now I understand it," said Louisa: "as the dimensions of an angle depend upon the number of degrees contained between its lines, it evidently must be the *opening*, and not the *length* of the lines, that determines the measure of the angle."

"Say, rather, the *value* of the angle, for that is the usual expression: but I perceive you understand me; tell me, therefore, how many degrees are contained in each of the two angles formed by one line falling perpendicularly on another, as in the above figure."

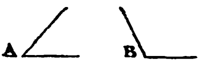
"I perceive that the two angles together are just equal to half the circle; and, since you say that the whole circle is divided into 360 degrees, each angle must measure 90 of them, or the two together make up 180."

"You are quite right, and I beg you to remember, that an angle of 90 degrees, is called a *right* angle, and that, when one line is perpendicular to another, it will always form, as you have just seen, a right angle on either side."

"I now understand," said Louisa, "what is meant by lines being at *right angles to each other:* But, papa," continued she, "what are *obtuse* and *acute* angles, of which I have so often heard you speak?"

Mr. Seymour replied, that he could better explain their nature by a drawing, than by any verbal description. "Here," said he, "is an acute angle, A; and here an obtuse one, B: the former, you perceive, is one

*Fig.* 2.



that contains less than 90 degress; the latter, one which contains more, and is consequently greater than a right angle."

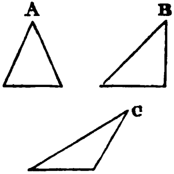
Louisa fully comprehended the explanation, and observed, that she should remember, whenever an angle measured less than a *right* angle, that it was *acute*, and when more, *obtuse*. But you have not yet explained to me," she continued, "the meaning of a *triangle*."

"That is a term denoting a figure of three sides, and angles. I dare say Tom can describe the several kinds of triangles."

Tom accordingly took the pencil, and drew a set of figures, of which the annexed are faithful copies.

"A," said he, "is an *Equi-lateral* triangle; its three sides being all equal. B is a *Right-angled* triangle, having one right angle. C represents an *Obtuse-angled* triangle, it having one obtuse angle. An *Acute-angled* triangle is one in which all the three angles are acute, as represented in figure A."

*Fig*. 3.



"As you have succeeded so well in your explanation of a triangle, let us see whether you can describe the nature of a circle."

"It is a round line, every part of which is equally distant from the centre."

"And which round line," said Mr. Seymour, "is frequently called the *circumference*. What is the diameter?"

"A straight line drawn through the centre, and terminating in the circumference on both sides."

"And an arc?" said Mr. Seymour.

"Any portion of the circumference."

"Now let me ask you, what name is given to a line which joins any two opposite angles of a four-sided figure?"

"The *diagonal*, papa."

"You are quite right," said Mr. Seymour; and, turning towards the girls, he desired them to remember that term, as they would frequently hear it mentioned during their investigation into the nature of "Compound Forces." "I really think," continued their father, "that Tom is as capable of instructing you in these elementary principles as myself; I shall, therefore, desire you, my dear boy, to conclude this lecture during my absence; remember, that by teaching others we always instruct ourselves: but before I quit you, I will give you a riddle to solve, for I well know that you all delight in an enigma."

"Indeed do we," said Louisa.

"Pray let us hear it, papa," cried Fanny.

Mr. Seymour then recited the following lines, which he had hastily composed; the point having, no doubt, been suggested on the instant, by the remark he had just offered.

"Here 's a riddle for those who delight in their gold,
Which they p'rhaps may explain, when my story is told;
No treasure 's so precious, and yet those who gain me,
Though they give me away, will always retain me!
Indeed, if they wish to increase their rich store,
By giving away, they will only add more!!
To Fancy's quick eye, in what forms have I risen,
And Poets declare that my birth was in heaven;
To some as a flame, as a stream, or a fountain,
To others I seem as a tower or mountain.
Should these hints not betray me, I only can say,
You do not possess me—I hope that you may."

"Why," cried Tom, "what can that be, of which the more we give away, the more we have left?"

"Ay," added Louisa, "and that we actually *increase* the store, by *giving away* a part of it!"

"It is some word, I think," observed Fanny; "do you not remember that mamma asked us what that was, from which we might take away *some*, and yet that the *whole* would remain?"

"To be sure," cried Tom, "I remember it well; it was the word *wholesome*."

Mr. Seymour here assured them, that the enigma they had just heard, did not depend upon any verbal quibble; and that as the object of its introduction was to instruct, rather than to puzzle them, he would explain it, and leave them to extract its moral, and profit by its application.

"It is KNOWLEDGE," said he.

"'*No treasure's so precious*,'" repeated Louisa; "certainly none;—'*and yet those who gain me, though they give me away, will always retain me*;—to be sure," added she. "How could I have been so simple as not to have guessed it? We can certainly impart all the knowledge we possess, and yet not lose any of it ourselves."

"By instructing others," said Mr. Seymour, "we are certain, at the same time, of instructing ourselves, and thus to increase our store of knowledge. Let this truth be impressed upon your memory, and, after our conversations, examine each other as to the knowledge you have gained by them: you will thus not only fix the facts more strongly in your recollection, but you will acquire a facility of conversing in philosophical language."

## CHAPTER VII.

COMPOUND FORCES.—THE COMPOSITION AND RESOLUTION OF MOTION.—ROTATORY MOTION.—THE REVOLVING WATCH-GLASS.—THE SLING.—THE CENTRIFUGAL AND CENTRIPETAL FORCES.—THEORY OF PROJECTILES.—A GEOLOGICAL CONVERSATION BETWEEN MR. SEYMOUR AND THE VICAR.

On the following morning, Mr. Seymour proceeded to explain the nature of "Compound Forces." The young party having assembled as usual, their father commenced his lecture by reminding his auditors, that the motion of a body actuated by a single force was always in a right line, and in the direction in which it received the impulse.

"Do you mean to say, papa, that a single force can never make a body move round, or in a crooked direction; if so, how is it that my ball, or marble, will frequently run along the ground in a curved direction: indeed, I always find it very difficult to make it go straight."

"Depend upon it, my dear, whenever the direction of a moving body deviates from a straight line, it has been influenced by some second force."

"Then I suppose that, whenever my marble runs in a curved line, there must be some second force to make it do so."

Undoubtedly; the inequality of the ground may give it a new direction; which, when combined with the original force which it received from your hand, will fully explain the irregularity of its course. It is to the consideration of such compound motion that I am now desirous of directing your attention: the subject is termed the "Composition of Forces." Here is a block of wood, with two strings, as you may perceive, affixed to it: do you take hold of one of these strings, Louisa: and you, Tom, of the other. That is right. Now place the block at one of the corners or *angles* of the table: and while Tom draws it along one of its sides, do you, Louisa, at the same time, draw it along the other."

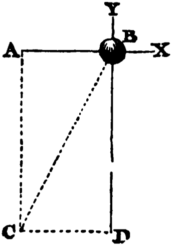
The children obeyed their father's directions.

"See!" said Mr. Seymour, "the block obeys neither of the strings, but picks out for itself a path which is intermediate. Can you tell me, Tom, the exact direction which it takes?"

"If we consider this table as a parallelogram, I should say, that the block described the diagonal."

"Well said, my boy; the ablest mathematician could not have given a more correct answer. The block was actuated by two forces at the same time; and, since it could not move in two directions at once, it moved under the *compound* force, in a mean or diagonal direction, proportioned to the influence of the joint forces acting upon it. You will, therefore, be pleased to remember, it is a general law, that where a body is actuated by two forces at the same time, whose directions are inclined to each other, at any angle whatever, it will not obey either of them, but move along the diagonal. In determining, therefore, the course which a body will describe under the influence of two such forces, we have nothing more to do than to draw lines which show the direction and quantity of the two forces, and then to complete the parallelogram by parallel lines, and its diagonal will be the path of the body. I have here a diagram which may render the subject more intelligible. Suppose the ball B were, at the same moment, struck by two forces X

*Fig.* 4.



and Y in the directions B A and B D. It is evident that the ball would not obey either of such forces, but would move along the oblique or diagonal line B C."

"But," said Tom, "why have you drawn the line B D so much longer than B A?"

"I am glad you have asked that question. Lines are intended, not only to represent the direction, but the *momenta*, or quantities of the forces: the line B D is, as you observe, twice as long as B A; it consequently denotes that the force Y acting in the direction B D, is twice as great as the force X acting in the direction B A. Having learned the direction which the body will take when influenced by joint forces of this kind, can you tell me the relative time which it would require for the performance of its diagonal journey?"

Tom hesitated; and Mr. Seymour relieved his embarrassment by informing him, that it would pass along the diagonal in exactly the same space of time that it would have required to traverse either of the sides of the parallelogram, had but one force been applied. Thus, the ball B would reach C in the same time that the force X would have sent it to A, or the force Y to D. "I will endeavour to prove this fact beyond all doubt. It is, I think, evident, that the force which acts in the direction B A can neither accelerate nor retard the approach of the body to the line D C, which is parallel to it; hence it will arrive at C in the same time that it would have done had no motion been communicated to it in the direction B A. In like manner, the motion in the direction B D can neither make the body approach to nor recede from A C; and it therefore follows, that, in consequence of the two motions, the body will be found both in A C and C D, and will therefore be found in C, the point of intersection."

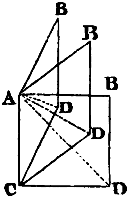
Louisa seemed to express by her looks the irksomeness of such demonstrations; and which did not pass unobserved.

"This may appear tedious and uninteresting," said Mr. Seymour, "but the information is absolutely essential to our future progress: if you would reap, you must sow."

Tom and Louisa both expressed themselves willing to receive whatever instruction their father might consider necessary; and they farther declared, that they understood the demonstration he had just offered them.

"Is it not then evident," proceeded Mr. Seymour, "that the composition of forces must always be attended with loss of power; since the diagonal of a parallelogram can never, under any circumstances, be equal to two of its sides? and is it not also evident, that the length of the diagonal must diminish as the angles of the sides increase: so that the more acute the angle at which the forces act, the less must be the loss by composition? But I shall be better able to explain this law by a diagram. If B A, A C be the sides of a parallelogram, representing the direction of two forces, and A D the diagonal path of the body, is it not evident that the line A D will shorten as the angle B A C increases?"

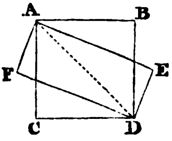
*Fig.* 5.



"We see that at once," cried Tom, "from the diagram before us."

"Then we will proceed to another fact connected with the same subject. Look at this diagram; is not the diagonal A D common to both the parallelograms inscribed about it, viz. of A B C D, and A E F D?"

*Fig.* 6.



"To be sure it is."

"Then it is equally clear, that

a body may be made to traverse the same path A D, by any pair of forces represented by the adjacent sides of either of such parallelograms."

"Undoubtedly."

"I request you to keep that fact in your recollection."

"I have now to inform you," continued he, "that a single force may be resolved into any number of forces, and may, in fact, be regarded as compounded of innumerable oblique ones. In order, however, to render this fact more intelligible, I must refer you to *fig*. 6, from which it will appear that the motion of a body, along the line A D, will be the same whether it arise from one single force acting in that direction, or from two forces impressed upon it in the directions A B, A C, or in those of A E, A F; and, consequently, although the motion may, in reality, be the effect of a single force, yet it may be considered as compounded of two or more in other directions, since the very same motion would arise from such a composition."

Tom acknowledged the truth of this statement; and Mr. Seymour assured him, that, when they came to play at ball and marbles, he should be able to give him a practical demonstration of the fact; for he would show him, that whenever a body strikes a surface obliquely, or in an inclined direction, such a *resolution of force* will actually take place: and now, Tom," said his father, "give me a marble; for I wish to explain the reason why it turns round, or revolves on its axis, as it proceeds forward."

"I suppose," said Tom, "it depends upon the action which I give to it by my thumb and finger when I shoot it out of my hand."

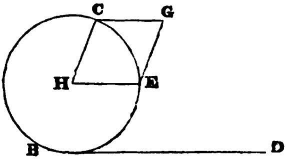
"You are, undoubtedly, capable of thus giving to your marble a certain *spinning* motion, the effect of which we shall have to consider hereafter;

but I fancy you would be greatly puzzled to make it proceed without revolving, give it what impulse you might by your hand."

"I have sometimes tried," said Tom, "to make it do so by pushing it along with a flat ruler, but it always *rolled* in spite of me."

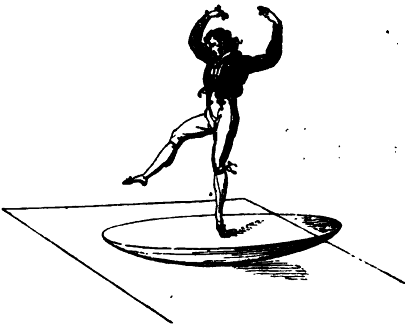
"Then it is clear, from your own experiment, that its rotation cannot arise from the cause you would assign to it. If you will attend to this diagram," continued his father, "I will endeavour to explain the operation. It is evident that, as the marble moves along the ground B D, the motion of the point B will be retarded by the resistance occasioned by its rubbing on the ground; while the point C, which does not meet with any such resistance, is carried forward without opposition, and it consequently must move faster than the point B; but since all the parts of the marble cohere or stick together, the point C cannot move faster than B, unless the marble revolves from C to E; and as the several points of the marble which are successively applied to the floor are retarded in their motion, while the opposite points move freely, the marble during its progressive motion must continue to revolve."

*Fig.* 7.



"But you said, papa, that whenever a body moved in any direction, except that of a straight line, it must have been acted upon by more than one force; and yet the marble not only runs along the ground, but turns round, at the same time, by the simple force of my hand."

"The revolution of the marble, my dear boy, is brought about by no less than three forces: look attentively at the diagram, and you will easily comprehend my explanation. There is, in the first place, the rectilinear motion given to it by your hand; then there is the friction of the ground: since, however, this latter acts in a contrary direction, it merely tends to lessen or counteract the velocity with which the under-surface proceeds, and consequently to give a relatively-increased progressive motion to its upper part; then comes that force by which its several parts cohere, and which may be represented by C H; so that the two forces producing the revolution of the point C, are justly expressed by the lines C G, C H: but these are in the direction of the two sides of a parallelogram, the point will therefore move along the diagonal C E. I have here a toy for you, which will serve to explain still farther the causes of rotation to which I have alluded." Mr. Seymour produced a watch-glass, in the hollow of which stood a dancing-figure of thin card, as here represented.



He placed it upon a black japanned waiter,* which he held in an inclined position, when it immediately slided down the inclined plane, as might have been expected. He next let fall a drop of water upon the waiter, and placed the watch-glass in it. Under this new arrangement, instead of sliding, the watch-glass began to revolve as soon as an inclination was given to the surface; and it continued to revolve with an accelerated velocity, obeying the inclination and position of the plane, as directed by the hand of the operator.

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* A common plate will answer the purpose; but the black surface gives the advantage of exhibiting more perfectly the motion of the water during the progress of the experiment.

"What a very pretty effect is produced by the rapid revolution of the figure!" observed Louisa.

"Its use in the arrangement," said her father, "is to render the accelerated motion more obvious."

"I perceive it revolves faster and faster, or, I suppose I ought to say, with an accelerated velocity," said Tom.

"Certainly," answered Mr. Seymour, "whenever a force continues to act, the motion produced by it must be accelerated for the reason already given you*—but let me explain the operation of the drop of water, which, as you have just seen, converted the sliding into the revolving motion. In the first place, in consequence of the cohesion of the water to the two surfaces, a new force was introduced, by which an unequal degree of resistance was imparted to different portions of that part of the watch-glass in contact with the plane, and, consequently, in its effort to slide down, it necessarily revolved. Now, if you will attentively observe the change of figure which the drop of water undergoes during the revolution of the glass, you will perceive a species of vortex; a film of water, by capillary action, is drawn to the foremost portion of the glass, while, by the centrifugal force, a body of water is thrown under the hinder part of it, the effect of both these actions is to accelerate the rotatory motion.

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* See page 54.

"I shall now dismiss the subject for the present, but on some future occasion I shall probably revert to it; for it may be made to afford a simple illustration of the rotatory and progressive motions of the earth round the sun; and it may also give us the means of producing some optical effects of a very curious kind." (15.)

Mrs. Seymour here suggested that, as it was past one o'clock, the children should be dismissed to their more active sports in the garden.

"We will instantly proceed to the lawn," replied Mr. Seymour, "and Tom may try his skill with the *sling;* an amusement which I have provided as a reward for his industry, and which will, at the same time, convey some farther information concerning the nature of those forces we have been just considering. The sling," continued his father, as he advanced upon the lawn, "consists, as you perceive, of a leathern thong, broadest in the middle, and tapering off gradually towards both ends. To each extremity is affixed a piece of string. I shall now place a stone in the broad part of the leather, and introduce my middle finger into the loop formed in one of the strings, and hold the other extremity between my fore-finger and thumb."

He then whirled it round, and when it had gained sufficient impetus, he let go his hold of the string, and the stone instantly shot forth with amazing velocity.

"See! see! there it goes," exclaimed Tom; "to what a height it ascended!"

"And to what a distance has it been projected!" observed Louisa, who had attentively watched its descent.

"Now, Tom," said his father, "can you explain the operation you have just witnessed?"

"Not exactly, papa."

"Then attend to me. Have you not learned that circular motion is always the result of two forces?"

"Undoubtedly," replied Tom; "of one force which attracts it to the centre around which it moves, and of another which impels it to move off in a right line."

"Certainly; the former of these forces is, therefore, termed the *centripetal*, because it draws the body towards the centre, while the latter is called the *centrifugal* force, since its influence disposes the body to fly off from the centre. In circular motion, these two forces constantly balance each other; otherwise it is evident that the revolving body must either approach the centre or recede from it, according as the one or the other prevailed. When I whirled round the sling, I imparted a projectile force to the stone, but it was prevented from flying off in consequence of the counteracting or *centripetal* force of the string; but the moment I let go my hold of this, the stone flew off in a right line: having been released from confinement to the fixed or central point, it was acted upon by one force only, and motion produced by a single force is, as you have just stated, always in a right line."

"But," observed Louisa, "the stone did not proceed in a straight, but in a curved line: I watched its direction from the moment it left the sling till it fell to the ground."

"You are perfectly correct," replied Mr. Seymour, "it described a curve, which is called a *parabola;* but that was owing to the influence of a new force which came into play, viz. that of gravity, the effect of which I shall have to explain hereafter."

"I cannot understand," said Tom, "why the stone should not have fallen out of the sling when you whirled it round over your head."

"Because," my dear, "it was acted upon by the *centrifugal* force, which contracted that of gravity: but I will render this fact more evident, by a very simple and beautiful experiment. I have here a wine-glass, around the rim of which I shall attach a piece of string so as to enable me to whirl it round. I will now fill it with water, and although during one part of its revolution it will be actually inverted, you will find that I shall not spill a single drop of water."

Mr. Seymour then whirled round the glass, and the young party were delighted with the confirmation thus afforded to their father's statement.

"I see," said Tom, "how it happened: when the glass was inverted the water could not fall out, because it was influenced by the centrifugal force which opposed gravity."

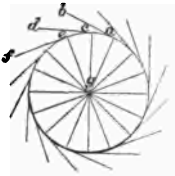
"Exactly. Have you ever observed what happens during the trundling of a mop? The threads which compose it fly off from the centre, but being confined to it at one end they cannot part from it; while the water which they contain being unconfined, is thrown off in right lines."

"I have certainly observed what you state," said Louisa; "the water flies off in all directions from the mop."

"Yes," added Tom, "the water was not acted upon by the *centripetal* force as the threads were, and consequently there was nothing to check the *centrifugal* force, which carried the water off in a straight line from the centre."

"You are not quite correct," said Mr. Seymour; "the water does not fly off in a right line from the centre, but in a right line in the direction in which it was moving at the instant of its release; the line which a body will always describe under such circumstances, is called a *tangent*, because it *touches* the circumference of the circle and forms a right-angle, with a line drawn from that point of the circumference to the centre: but I will render this subject more intelligible by a diagram. Suppose a body, revolving in the circle, was liberated at *a*, it would fly off in the direction *ab;* if at *c*, in that of *cd;* and if at *e*, in that of *ef;* and so on. Now, if you draw lines from these several points to the centre of the circle, you will perceive that such lines will form, in each case, a right-angle. In the experiment which you have just witnessed, the surface of the water must have formed, during its revolution, a right-angle with the string, and consequently could not have fallen out of the wine-glass. A knowledge of this law," continued Mr. Seymour, "will explain many appearances which, although familiar, I dare say, have never been understood by you. You may remember accompanying me to the pottery, to see the operation of the turning-lathe; it was owing to the centrifugal force produced by the rotation of the wheel, that the clay, under a gentle pressure, swelled out so regularly; from a similar cause, the flour is thrown out of the revolving mill as fast as it is ground; and I shall presently show you that you are indebted to this same force for the spinning of your top and the trundling of your hoop. But let us quit this subject for the present, and pursue the stone in its course after it is liberated from the sling. Louisa has justly observed that it described a curve; can you explain why it should deviate from a straight line?"

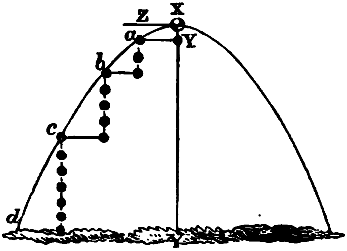
*Fig.* 8.



"Let me see," said Tom, thoughtfully; "it would be acted upon by two forces, one carrying it forward in a right line, the other bringing it to the earth; it would, therefore, not obey either, but describe a diagonal: but why that diagonal should be a curve I cannot exactly explain."

"Then I will give you the reason," said his father. "A stone projected into the air is acted upon by no less than three forces; the force of projection, which is communicated to it by the hand or the sling; the resistance of the air through which it passes, and which diminishes its velocity without changing its direction; and the force of gravity, which ultimately brings it to the ground. Now, since the power of gravity and the resistance of the air will always be greater than any force of projection we can give a body, the latter must be gradually overcome and the body brought to the ground; but the stronger the projectile force the longer will those powers be in subduing it, and the farther will the body go before it falls. A shot fired from a cannon, for instance, will go much farther than a stone thrown from your hand. Had the two forces which acted upon the stone, viz. those of projection and gravity, both produced uniform motion, the body must certainly have descended through the diagonal; but since gravity, as you have already learned, is an accelerating force, the body is made to describe a curve instead of a straight line. This law, however, will require the aid of a diagram for its explanation. Let X represent the ball at its greatest altitude, X Y the force of gravity drawing it downward; and X Z that of projection. We have here, then, two forces acting in the direction of

*Fig.* 9.



the two sides of a parallelogram. In passing on to z, the ball will perform the diagonal x *a*; and in the next equal space of time, will descend through *three* times the distance z *a*, and will consequently be found at *b*; while in the next period it will fall through *five* equal spaces, and pass to *c*; and in the next period, again, as it must fall through *seven* such spaces, it will reach the ground at *d*, having described a portion of a curve from x to *d*, or during the time that the two forces were in simultaneous operation. The same principle will explain the curved ascent of the ball, substituting only the laws of retarded for those of accelerated motion; for it is clear that the body during its *ascent*, will be retarded in the same degree in which it was accelerated during its *descent*."

"Your explanation," said Louisa, "appears very clear and satisfactory."

"The curve which *Projectiles* (that is to say, bodies projected into the air) describe, is termed a *Parabola* (16), although the resistance of the air, which is not recognised in the theory, produces a considerable influence on the practical result."

The children now proceeded to amuse themselves with the sling. Louisa challenged Tom to a trial of skill. She fancied that she could hurl a stone with greater accuracy than her brother; but after several contests she acknowledged herself vanquished, for Tom had succeeded in striking the trunk of an old tree at a considerable distance, while his sister was never able to throw the stone within several yards of the mark.

"Well done, Tom!" exclaimed Mr. Seymour; "why you will soon equal in skill the ancient natives of the Balearic Islands!"

"And were they famous for this art?" asked Louisa.

"With such dexterity," replied her father, "did they use the sling, that we are told their young children were not allowed any food by their mothers, except that which they could fling down from the beam where it was placed aloft. I fancy, however, Tom, that you would become very hungry before you could strike an object in yonder poplar."

"At all events, I will try," said Tom.

He accordingly whirled round his sling, and discharged its stone, which flew forward with great velocity, but in a direction very wide from the mark at which it was aimed. In the next moment a violent hallooing was heard: it was from the vicar, who had narrowly escaped the boisterous salutation of the falling stone, which, in its anxiety to throw itself at the feet of the reverend gentleman, struck the beaver penthouse that defended his upper story, and by a resolution of forces which we have endeavoured to explain, darted off in the direction of the side of a parallelogram, and was thus averted from the equally sensitive antipodes of his venerable person, the brains in his head, and the corns in his shoes.

"Upon my word, young gentleman!" cried the vicar, "I expected nothing less than the fate of the giant of Gath."

"My dear Mr. Twaddleton," exclaimed Tom, in a tone of alarm, "I sincerely hope that you have not been struck?"

"O no! thanks to my clerical helmet, I have escaped the danger which threatened me: but, tell me, what new game is engaging your attention?"

Mr. Seymour said that he had been explaining the scientific principle of the sling, and that he hoped the vicar was prepared to afford them some information respecting its invention and history.

"The art of slinging, or casting stones," replied the vicar, "is one of the highest antiquity, and was carried to a great degree of perfection amongst the Asiatic nations. It was well known and practised at a very early period in Europe; and our Saxon ancestors appear to have been very expert in the use of this missile."

Mr. Twaddleton being desirous of communicating the history of Major Snapwell, begged that Mr. and Mrs. Seymour would allow him a few minutes' conversation; observing that the attention of the children would be agreeably occupied during their absence by their newly-acquired amusement.

"We will then, if you please, vicar," replied Mr. Seymour, "walk to the Geological Temple, where I have lately deposited some specimens which you have not yet seen."

"To speak sincerely," said the vicar, "I cannot participate in that high satisfaction which you appear to feel in collecting such hordes of broken rocks and pebbles: where can lie the utility of such labour? unless, indeed, in pursuance of your Utopian plans, you intend to *Mac-adamise* all the roads of science."

"Is it nothing, my dear Mr. Twaddleton, to discover the structure of different countries?"

"Which the geologist infers," replied the vicar, "from a few *patterns*, picked up at random on the road side!"

"Mr. Twaddleton," said Mr. Seymour, "I will meet you on your own ground: you are an antiquary; if an ancient monument of art be so inestimable, is not a knowledge of the antiquity of the globe itself, at least, of equal interest?"

"I understand you; you would infer that the scriptural account of the Deluge is disproved by those Sciolists, who pretend to discover the antiquity of the globe by penetrating its caverns, with as much ease as the jockey ascertains the age of a horse by looking into its jaws."

"You speak too flippantly of a class of philosophers who have united their efforts to investigate a sublime subject upon the true principles of science; were you to attend the meetings of the Geological Society, and hear the discussions of its members. you would cease to talk thus irreverently."

"Although I may be unknown to your genii of the mountains, I am, at all events, acquainted with a kindred class of philosophers who rival them in industry, if not in talents; and notwithstanding the limited range of their observations—being confined to the mountainous districts they inhabit—I have little doubt but that their labours have proved as acceptable to the world as those of the disciples of Hutton or Werner. I once visited this district, and although the language of its inhabitants was entirely unknown to me, I soon discovered, by the aid of a glass, that they were in serious discourse with each other; and one of the elders of the fraternity, who was seated on a craggy precipice that overhung an extensive valley covered with rich verdure, appeared, from his gestures, as if pointing out to his fellow-labourers, who were digging in all directions in search of treasure, the danger of an approaching convulsion. While I was yet gazing, the fatal catastrophe actually occurred; immense masses of the tottering strata rolled with precipitous haste into the valley, involving in its ruin hundreds of its inhabitants. It was extraordinary to behold the effect of this shock upon those who were beyond the reach of its more destructive influence; hundreds were seen scaling heights that appeared inaccessible; others, stumbling—falling down frightful precipices—rising again—helping, or pushing each other on—the foremost serving as so many stepping-stones to those behind, who, in their turn, hauled up the clusters over whose backs they had so unceremoniously vaulted."

"How awful!" cried Mrs. Seymour; "I never heard of any modern catastrophe of such fearful extent: where did it occur."

"The vicar doubtless alludes to the terrible earthquake of Messina, or perhaps to that of Lisbon."

"I neither allude to the one nor to the other," cried Mr. Twaddleton; "and yet, in some respects, the catastrophe which I have described resembled that of Lisbon; for during the dreadful disaster human beings were seen to take advantage of the confusion to murder many of the inhabitants, and to pillage their territories." (17)

"For goodness' sake," cried Mrs. Seymour, "tell us at once where this terrible event occurred."

"In a fine Cheshire cheese!" exclaimed the vicar, "which had furnished abundant food to the miniature republic of mites that occupied its deep ravines and alpine heights. I think now," continued the reverend gentleman, "I am amply revenged for the allegorical jokes in which Mr. Seymour has so often indulged at my expense."

"I am well satisfied," said Mr. Seymour; "for by repeating your allegory to my children, I shall be enabled to convey a striking lesson of wisdom. They will learn from it that there is not any pursuit, however exalted, that may not be assailed by the weapons of ridicule, especially when wielded by those penurious philosophers whose ideas of utility are circumscribed within the narrow limits of direct and immediate profit."

"It is too true," cried Mrs. Seymour, "that we are all apt to depreciate those branches of knowledge which do not bear directly upon the comforts or necessities of life; and the applications of geology are, perhaps, so remote as scarcely to be discovered by the mass of mankind."

"There I must differ with you," replied her husband: "to say nothing of the practical advantages which have accrued to the miner from this study, it has been the means of bringing hundreds of acres into cultivation in districts where never a blade of grass had before grown; (18) and if scholastic researches have thrown additional light on scriptural subjects, they are no more to be compared with those of the geologist on these occasions than is the light of the glow-worm to that of the sun."

"Hey-day! what do I hear?" exclaimed the vicar. "Would you compare the testimony of the Apamean medal with that of an unshapen flint?"

"I would rest my faith upon a *rock*," replied Mr. Seymour; "the caves of Buckland (19) have done more towards supporting the Mosaic account of the Deluge than all the medals of the virtuoso. Fossils, in truth, are to the geologist, what medals are to the antiquary, preserving a record of events which must otherwise have perished in the stream of time."

Mr. and Mrs. Seymour and the vicar by this time arrived at the Wernerian Temple, where having discussed several points connected with its objects, Mr. Twaddleton gave an account of Major Snapwell, whose history created considerable interest, and determined Mr. Seymour to call at Ivy Cottage, and invite its inmate to the lodge.

# CHAPTER VIII.

THE SUBJECT OF ROTATORY MOTION CONTINUED.—A BALL, BY HAVING A PECULIAR SPINNING MOTION IMPARTED TO IT, MAY BE MADE TO STOP SHORT, OR TO RETROGRADE THOUGH IT MEETS NOT WITH ANY APPARENT OBSTACLE.—THE RECTILINEAR PATH OF A SPHERICAL BODY INFLUENCED BY ITS ROTATORY MOTION.—BILBOQUET, OR CUP AND BALL.—THE JOINT FORCES WHICH ENABLE THE BALANCER TO THROW UP AND CATCH HIS BALLS ON THE FULL GALLOP.—THE HOOP.—THE CENTRE OF PERCUSSION.—THE WHIP AND PEG-TOP.—HISTORICAL NOTICES.—THE POWER BY WHICH THE TOP IS ENABLED TO SUSTAIN ITS VERTICAL POSITION DURING THE ACT OF SPINNING.—THE SLEEPING OF THE TOP EXPLAINED.—THE FORCE WHICH ENABLES IT TO RISE FROM AN OBLIQUE INTO A VERTICAL POSITION.—ITS GYRATION.

"TOM, do you remember that I told you a few days ago," said Mr. Seymour, "that, by giving a revolving body a peculiar *spinning* motion, certain effects were produced, which I should, on some future occasion, take into consideration?"

"To be sure I do," replied Tom.

"Well, then, attend to me."

Mr. Seymour took a marble, and, placing it on the ground, gave it an impulse forward by pressing his forefinger upon it: the marble darted forward a few paces, after which it rolled back again.

"That is most extraordinary!" cried Tom; "the marble came back to your hand, as it were, of its own accord, and without having met with any obstacle."

"And you, no doubt," said Mr. Seymour, "regard it as contrary to the well known law, that a body once put in motion, in any direction, will continue to move in that direction until some foreign cause oppose it."

"It really would appear so."

"It is, however, far otherwise; the force which I imparted to the marble communicated to it two kinds of motion; the one projecting it forward, the other producing a rotatory motion round its axis, in a direction opposite to that of its rectilinear course; and the consequence was simply this, that when the former motion, on account of the friction of the marble on the ground, was destroyed, the rotatory motion continued, and by thus establishing an action in an opposite direction, caused the marble to retrograde. If, however, you will fetch your hoop, I will demonstrate the fact on a larger scale."

Tom accordingly produced the hoop; and Mr. Seymour projected it forward, giving to it, at the same instant, a spinning motion in an opposite direction. The hoop proceeded forward to a certain distance, when it stopped, and then ran back to the hand.

"Let me beg you," said Mr. Seymour, "to treasure this fact in your memory; you perceive by it how greatly the progressive direction of a body may be influenced by a rotatory motion around its axis; and, indeed, the theory of the *rifle* gun (20) is easily deduced from it. It will also explain the effect which a rotatory motion produces in steadying or disturbing the direction of a projectile. It is for such a reason that the balancer constantly whirls round his balls or oranges, as he throws them into the air, with the intention of catching them again; and that in playing at *Bilboquet*, or cup and ball, you find it necessary to give a spinning motion to the ball, in order to catch it on the spike—but we will consider this subject presently. I am now desirous of laying down a few propositions upon the subject of rotation, the knowledge of which is essential for the explanation of the motions of revolving bodies."

Mr. Seymour proceeded to state that every body had three principal axes upon which it might revolve, but that the shortest was the only one upon which it could permanently and steadily rotate—that should it, in consequence of the impulse given to it, begin to spin upon any other than the shortest axis, it would, during its revolutions, be constantly showing a tendency to approach it; whence it followed that, under such circumstances, it would be unsteady and *wabbling* in its motions.

In order, however, to make this proposition intelligible to the children, Mr. Seymour performed the following simple experiment.

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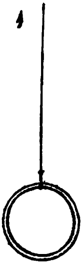

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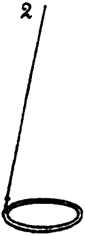


Having tied some string to a common curtain ring, as represented by figure 1, he twisted it round by means of his thumb and finger, until it acquired considerable velocity, when the ring was seen to rise gradually into the position represented by fig. 2. Thus, in the simplest manner, was a revolving body shown to exchange its longer for its shorter axis.

The children declared that they perfectly comprehended the subject, and Tom observed that, in future, whenever he wished to make a ball spin steadily, he should take care to make it turn on its shortest axis.

"You are quite right, Tom," said Mr. Seymour, "and the skilful bowler at cricket, in order to give his ball a steady axis of rotation, always holds it with the seam across, so that the tips of his finger may touch, and he takes care to hold it only with such a grasp as may be sufficient to steady it, for by a turn even of the wrist it may be made to proceed unsteadily; and this leads me to consider another equally important proposition—viz. that the axis of rotation should coincide with the direction in which it is moving forward, or, in other words, with its line of motion. Now, where this is not the case, it is evident that the unequal action of the air will cause the body to deviate from its straight course, since its two sides, having different velocities (the rotatory and progressive motions conspiring on one side, while they are in opposition on the other), will be differently affected by such resistance; the resistance, of course, increasing with the velocity. It is upon this principle," continued Mr. Seymour, "that Sir Isaac Newton has explained the irregular motion of the tennis-ball."

"But do explain to us, papa," said Louisa, "why it is so necessary to spin the ball in order to catch it on the spike?"

" Rotatory motion, my dear, when directed according to the principles I have endeavoured to enforce, will always steady the course of a body. In playing at bilboquet, your object is so to throw up the ball that its hole may descend perpendicularly upon the spike which is held for its reception; and in order to accomplish this, you make the ball spin upon an axis, at the extremity of which is the hole; the consequence is obvious.

Louisa observed, that she well remembered an allusion to this game in Miss Edgeworth's Essays on Education; and that, unless she was much deceived, the advantage to be gained by spinning the ball was referred to centrifugal force, and its effect in preserving the '*parallelism of motion*."

" I do not recollect the passage," answered her father, " but I will admit that the centrifugal force is indirectly instrumental to the effect, although, in my view of the subject, it is more philosophical to refer it at once to the creation of an appropriate axis of rotation."

" I well remember," observed Tom, " that the rider at Astley's whirled round the oranges as he threw them into the air."

" And I hope that you are now acquainted with the principle which rendered such a rotatory motion necessary: but can you tell me how it could have happened, that the oranges, which were thrown perpendicularly upwards, while the horseman was on the full gallop, should have fallen again into his hand?"

" Ay," said Louisa, " that puzzled me exceedingly; I should have thought he would have ridden away from them, and that they must have fallen several feet behind him."

" What say you, Tom, to that?" enquired Mr. Seymour.

" I suppose," replied Tom, " that the rider calculated upon the distance he would pass forward, before they could fall, and projected them accordingly."

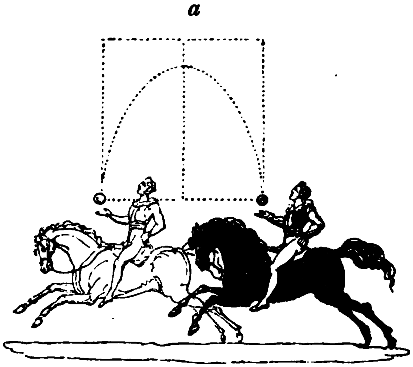
"No, indeed; there is no calculation in the case, nor is any art used to throw the oranges in advance: they are projected perpendicularly from the hand; and if you will only recall to your mind the subject of the 'Composition of Forces,' the mystery will vanish."

"I see it all clearly," cried Tom; "the orange partakes of the progressive motion of the rider; when, therefore, he throws it upwards, it is influenced by two forces which are in the direction of the two sides of a parallelogram, and it consequently describes the diagonal."

"You are quite right; but you doubtless will perceive that, instead of a straight line, the orange will describe a parabolic curve."

"For the same reason, I suppose," said Tom, "that the stone from the sling described a curve?"

"Certainly; but see, I have a diagram which will explain the subject more clearly.



The orange, as it is thrown into the air, is influenced by two forces; the one arising from the progressive motion of the rider, the other from the projectile force imparted to it. These two forces are in the direction of the adjacent sides of a parallelogram, and were it not for the operation of gravity, the body would accordingly describe its diagonal in the same space of time as it would have described one of the sides.* The influence of gravity, however, not only deflects it from a right line into a curve, but diminishes its force, so that instead of arriving at the opposite angle of the parallelogram *a*, its greatest altitude will be short of that point; it will then descend through a similar curve; and, since the times of ascent and descent are equal †, it will reach the hand of the rider at the very moment he is prepared to receive it; for the orange will have traversed the parabolic curve in the same space of time as the horseman required for passing from one extremity of the curve to the other."

Mr. Seymour having concluded this explanation, much to the satisfaction of the young party, observed that the present occasion was an appropriate one for the introduction of some remarks on the favourite pastime of the Hoop.

"It is a classical pastime," exclaimed the vicar, "and was as common with the Greeks and Romans as it is with boys of the present generation."

"And it has the advantage," added Mr. Seymour, "of sending the tide of life in healthful currents through the veins."

Tom began to trundle his hoop along the gravel walk.

"Stop, stop, my dear boy," cried his father, "you seem to have forgotten our compact, that every toy should be fairly won, before it was played with. Come upon the lawn, and let me ask you some questions relative to the motions of the hoop. Can you make it stand still upon its edge?"

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* See page 120. † See page 155.

"Not readily," was Tom's reply.

"And yet," continued Mr. Seymour, "during its progressive motion, it rolls on its edge without any disposition to fall: how happens that?"

"It is owing to the centrifugal force, which gives it a motion in the direction of a *tangent* to the circle, and, consequently, overcomes the force of gravity."

"Your answer is pat," replied his father: "as long as you give your hoop a certain degree of velocity, the *tangential*, or centrifugal force, overcomes gravity, in the manner you have already witnessed*; but, when that is slackened, the hoop will fall on its side; not, however, until it has made several complete revolutions. Now, answer me another question. Why it is so difficult to make the hoop proceed straight forward, without turning to the right or left?"

"I suppose it arises from the same cause as that which altered the direction of my marble as it ran along—the inequality of the ground."

"That," replied his father, "would undoubtedly have its influence; but it is principally to be referred to the impossibility of your constantly giving a straight blow by the stick. When it is moving forward, a slight inclination towards either side will cause the parts to acquire a motion towards that side, those which are uppermost being most affected by it; and this lateral, or sideway motion, assisted sometimes by the irregular curvature of the hoop, causes its path to deviate from a rectilinear direction; so that, instead of moving straight forward, it turns to that side towards which it began to incline; and, in this position, its tendency to fall is still farther counteracted by the centrifugal force. It is from a similar cause that the bullet, unless rifled, will have a tendency to go to the right or left, from any unequal impulse which it may have received at the moment of its exit from the barrel. I have yet one other question, and, as its answer will lead us into the consideration of a mechanical subject of some importance, I must beg you to bestow all your attention. In trundling your hoop, have you not often observed that, although the blow inflicted upon it by your stick might have been violent, yet the effect produced by it was comparatively small, in consequence of the hoop having been struck by a disadvantageous part of the stick?"

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* See page 128.

"Certainly! I have frequently observed that, if the hoop is struck by the stick either too near the hand, or too near the end, much of its force is lost; and I have also noticed the same thing in striking the ball with my cricket bat."

"The fact is," said Mr. Seymour, "that every striking body has what is termed its *centre of percussion*, in which all the percutient force of a body is, as it were, collected; thus, a stick of a cylindrical figure, supposing the centre of motion at the hand, will strike the greatest blow at a point about two-thirds of its length from the wrist. I may, perhaps, at some future time, return to this subject, and explain several mechanical effects which are dependant upon it. (21) Now away with you, and trundle your hoop, or spin your top; as soon as the vicar arrives I will rejoin you."

In the course of an hour Mr. Seymour and his reverend friend proceeded to the play-ground, where they found the children busily engaged in their several diversions.

"I rejoice to find you at so classical a pastime," said the vicar, as he approached Tom, who was busily engaged in spinning his top. The top, my boy, is a subject which the great Mantuan bard did not consider beneath the patronage of his muse: but, hey-day! this is not the '*volitans sub verbere turbo*' of the immortal Virgil; the top of antiquity was the whip-top, the peg-top is a barbarous innovation of modern times; a practical proof of the degeneracy of the race. Even boys, forsooth, must now-a-days have their activity cramped by inventions to supersede labour: well may we regard the weapons, which our sturdy ancestors wielded, as instruments rather calculated for giants than men, if such pains be taken to instil into the minds of youth the mischievous spirit of idleness."

"My dear sir," said Tom, who was always grieved at displeasing the vicar, "if it will gratify you, I will spin my *whip*-top, for I have an excellent one which my papa has lately given me."

"Well said! my dear boy. '*Puer bonæ spei.*' —What a pity would it be to damp so noble a spirit; get your whip-top."

Tom accordingly placed the Virgilian top upon the ground, and as the boy plied the whip, so did the vicar lash the air with his quotation; running round the top in apparent ecstasy, while he repeated the well-known lines from the seventh Æneid:—

> "Ille actus habena
> Curvatis fertur spatiis; stupet inscia turba,
> Impubesque manus, mirata volubile buxum:
> Dant animos plagæ." *

As Mr. Twaddleton thus gave vent to that fervour which was ever kindled by collision with Virgil, Tom gave motion to his top, which swaggered about with such an air of self-importance, that, to the eye of fancy, it might have appeared as if proudly conscious of the encomiums that had been so liberally lavished upon it.

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* "The wooden engine flies and whirls about,
Admired, with clamours, of the beardless rout:
They lash aloud; each other they provoke,
And lend their little souls at every stroke."—DRYDEN.

"The Grecian boys, as Suidas informs us, played also with this top," continued the vicar.

"And pray, may I ask," said Mr. Seymour, "whether it was not introduced into this country by the Romans?"

"Probably," replied the vicar. "Figures representing boys in the act of whipping their tops first appear in the marginal paintings of the manuscripts of the fourteenth century; at which period, the form of the toy was the same as it is at present, and the manner of impelling it by the whip can admit of but little if any difference. In a manuscript*, at the British Museum, I have read a very curious anecdote which refers to Prince Henry, the eldest son of James the First; with your permission I will relate it to you."

Here the vicar extracted a memorandum-book from his pocket, and read the following note:—

"The first tyme that he, the prince, went to the towne of Sterling to meete the king, seeing a little without the gate of the towne a stack of corne, in proportion not unlike to a topp, wherewith he used to play, he said to some that were with him, 'Loe there is a goodly topp:' whereupon one of them saying, 'Why doe you not play with it then?' he answered, 'Set you it up for me, and I will play with it.'"

"Was not that a clever retort of the young prince?" said the vicar, as he returned the manuscript into his memorandum-book; "and I think it must have confounded the courtier who could have asked so silly a question."

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* Harl. lib. i. marked 6391.

"Well, Tom," said Mr. Seymour, "let us see whether you can set up your own top, so that it shall stand steadily on its point."

"I have often tried that experiment," answered Tom, "but could never succeed in keeping the line of direction within its narrow base."

"And yet, when in rotatory motion, its erect position is maintained without difficulty; how is that?"

"Is it not owing to the centrifugal force?" asked Tom.

"Undoubtedly: but as the subject is highly interesting, I will endeavour to explain it more fully. You must, however, first obtain permission from the vicar to spin your humming-top, for that will better illustrate the phenomena which it is my wish to examine."

"If your object is the exercise of the body, let us spin the whip-top," replied the vicar; "but if you wish to exercise the boy's mind, I cannot object to your selecting the top best calculated to fulfil that desire."

Tom having accordingly prepared his top, pulled the string, and set the wooden machine spinning on the floor.

"Now, Tom, I will explain to you the reason of the top being able to sustain its vertical position. You have already learned, from the action of the sling, that a body cannot move in a circular path, without making an effort to fly off in a right line from the centre *; so that, if a body be affixed to a string, and whirled round by the hand, it will stretch it, and in a greater degree according as the circular motion is more rapid."

"Certainly," said Tom.

"The top, then, being in motion, all its parts tend to recede from the axis, and with greater force

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* Page 126.

the more rapidly it revolves: hence it follows that these parts are like so many powers acting in a direction perpendicular to the axis; but, as they are all equal, and as they pass all round with rapidity by the rotation, the result must be that the top is in equilibrio on its point of support, or on the extremity of the axis on which it turns. But see, your top is down."

"And what is the reason," asked Tom, "of its motion being stopped?"

"I can answer that question, papa," said Louisa; "is it not owing to the friction of the ground?"

"Certainly; that has, doubtless, its influence: but the resistance of the air is also a powerful force upon this occasion. A top has been made to spin in vacuo as long as two hours sixteen minutes*. But come, Tom, spin your top once more. Observe," exclaimed Mr. Seymour, "how obliquely the top is spinning. It is now gradually rising out of an oblique position;—now it is steadily spinning on a vertical axis;—and now its motion is so steady, that it scarcely seems to move."

"It is *sleeping*, as we call it," said Tom.

"Its centre of gravity is now situated perpendicularly over its point of support, which is the extremity of the axis of rotation: but attend to me," continued Mr. Seymour, "for I am about to attempt the explanation of a phenomenon which has puzzled many older and wiser philosophers than yourselves. It is evident that the top, in rising from an oblique to a vertical position, must have its centre of gravity raised; what can have been the force which effected this change?"

"Was it the centrifugal force?" asked Tom.

"Certainly not," said Mr. Seymour, "as I will presently convince you."

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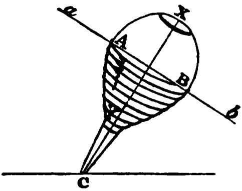
* Short on 'Serson's Horizontal Top.' Phil. Trans. vol. xlvii. p. 352.

“Then it must have been the resistance of the air,” said Louisa.

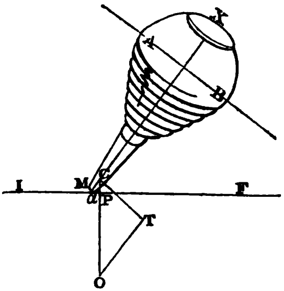
“No; nor was it the resistance of the air,” replied her father: “for the same effect takes place in vacuo.”

“Then pray inform us, by what means the top was raised.”

“It entirely depended upon the form of the extremity of the peg, and not upon any simple effect connected with the rotatory or centrifugal force of the top. I will first satisfy you that, were the peg to terminate in a fine, that is to say, in a *mathematical* point, the top never could raise itself. Let A B C be a top spinning in an oblique position, having the end of the peg, on which it spins, brought to a fine point. It will continue to spin in the direction in which it reaches the ground, without the least tendency to rise into a more vertical position; and it is by its rotatory or centrifugal force that it is kept in this original position: for if we conceive the top divided into two equal parts A and B by a plane passing through the line X C, and suppose that at any moment during its spinning, the connection between these two parts were suddenly dissolved, then would any point in the part A fly off with the given force in the direction of the tangent, and any corresponding point in the part B with an equal force in an opposite direction; whilst, therefore, these two parts remain connected together, during the spinning of the top, these two equal and opposite forces A and B will balance each other, and the top will continue to spin on its original axis. Having now shown that the rotatory or centrifugal force can never make the top rise from an oblique to a



vertical position, I shall proceed to explain the true cause of this change, and I trust you will be satisfied that it depends upon the bluntness of the point. Let A B C be a top spinning in an oblique position, terminating in a very short point with a hemispherical shoulder P *a* M. It is evident that, in this case, the top will not spin upon *a* the end of the true axis X *a*, but upon P, a point in the circle P M, to which the floor I F is a tangent. Instead, therefore, of revolving upon a fixed and stationary point, the top will roll round upon the small circle P M on its blunt point, with very considerable friction, the force of which may be represented by a line O P at right angles to the floor I F, and to the spherical end of the peg of the top: now it is the action of this force, by its pressure on one side of the blunt point of the top, which causes it to rise in a vertical direction. Produce the line O P till it meets the axis C; from the point C draw the line C T perpendicular to the axis *a* X, and T O parallel to it; and then, by a resolution of forces, the line T C will represent that part of the friction which presses at right angles to the axis, so as gradually to raise it in a vertical position; in which operation the circle P M gradually diminishes by the approach of the point P to *a*, as the axis becomes more perpendicular, and vanishes when the point P coincides with the point *a*, that is to say, when the top has arrived at its vertical position, where it will continue to *sleep*, without much friction, or any other disturbing force, until its rotatory motion fails, and its side is brought to the earth by the force of gravity."



"I *think* I understand it," said Tom, "although I have some doubt about it; but if you would be so kind as to give me the demonstration in writing, I will diligently study it."

"Most readily," said Mr. Seymour. "Indeed I cannot expect that you should comprehend so difficult a subject, without the most patient investigation; and, in the present state of your knowledge, I am compelled to omit the relation of several very important circumstances, to which I may, hereafter, direct your attention. When, for instance, you have become acquainted with the elements of astronomy, I shall be able to show you that the gyration of the top depends upon the same principles as the precession of the equinoxes. (22)

## CHAPTER IX.

TRAP AND BALL.—GIFTS FROM THE VICAR.—AN ANTIQUARIAN HISTORY OF THE BALL.—THE SEE-SAW.—THE MECHANICAL POWERS.—THE SWING.—THE DOCTRINE OF OSCILLATION.—GALILEO'S DISCOVERY.—THE PENDULUM.—AN INTERESTING LETTER.—MR. SEYMOUR AND THE VICAR VISIT MAJOR SNAPWELL.

MR. SEYMOUR having observed his children busily engaged at the game of Trap and Ball, determined, as usual, to make it subservient to scientific instruction. With this view he hastily sketched a diagram, and proceeded with it to the scene of sport.

"Now, Tom, let me see how far you have profited by our late conversation. I have some questions to ask you about the action of your Trap and Ball," said his father.

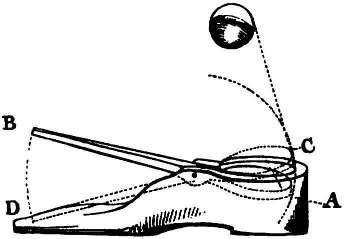
"I do not suppose there is much philosophy in the game," observed Tom.

"Of that we shall judge presently—Can you tell me the direction which the ball takes after it flies from the spoon of the Trap, in consequence of the blow of the bat upon the trigger?"

"It flies upwards, to be sure, and allows me to strike it with my bat," answered the boy.

"Very true; but at what angle?—I see you hesitate, look therefore at the diagram I have prepared, and attend to my explanation of it."

Mr. Seymour produced the sketch which we here present to our readers.



A B represent the spoon and trigger in their quiescent position. Upon striking the end B with the bat, they are brought into the position C D. The spoon will thus have described the small arc A C, when it will be suddenly stopped by the end of the trigger D coming into contact with the shoe. The motion of the ball, however, will not be arrested, and it will consequently be projected forward out of the spoon."

"Exactly," exclaimed Louisa, "in the same manner as the shilling flew off the wine glass, or a person on a galloping horse would be thrown over the head by its suddenly stopping."

"I thank you, Louisa; your memory, I perceive, has not suffered from the drenching you received from the water cart*—but can you tell me," continued Mr. Seymour, "the direction which the ball will take *after* its release from the spoon."

This was a step beyond Louisa's knowledge, and her father, in order to assist her, begged her to consider in what direction it was moving *before* it left the spoon.

"You have just told us," said Tom, "that it described an arc, or portion of a circle.

"Very well," said Mr. Seymour, "and did not the philosophy of your sling teach you that, when a body revolving in a circle is suddenly disengaged, it will fly off in a right line in the direction in which it was moving at the instant of its release—the ball therefore will describe the tangent C E.

"It is all clear enough to me now," said Tom, evidently vexed that he had overlooked a principle which had been so lately explained to him by the action of his sling.

"I now see too," added Tom, "why the ball seldom flies off at the same angle in every trap."

"That," said his father, "must of course depend upon the extent of the arc described by the spoon, and which will of course vary in different traps.

Before we conclude the subject, let me ask you whether there is not some one point in the bat, at which you can most effectually strike the ball?"

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* See page 16.

"To be sure," answered Tom, "in the same way that there is a point in my hoop-stick at which I can give the strongest blow—and that point is termed the *Centre* of Percussion."

"Enough," said Mr. Seymour; "see here comes the vicar."

True to the hour appointed, did Mr. Twaddleton make his appearance, just at the conclusion of the discussion above described; and, as he approached the party, Louisa observed that he was carrying a canvass bag in his hand.

"What have you there?" asked Mr. Seymour. "A sack of sugar-plums?"

"No, no; spheres of larger diameter. Here," said the vicar, as he opened his bag, "is a foot-ball for you, Tom; and here is a hand-ball for you, Louisa. He then presented each of the other children with a similar present, exclaiming—

> "Nemo ex hoc numero mihi non donatus abibit.[*]

as Virgil has it."

"Perhaps," said Mr. Seymour, "you will enhance the value of this favour, by giving us an antiquarian history of the ball, which will be very acceptable to us at this time, as we have just concluded a philosophical enquiry upon that subject."

To this request the vicar readily assented, and proceeded as follows:—

"The Greeks appear to have played with four kinds of ball; viz. the *little ball*, the *great ball*, the *empty ball* (σφαιρα κενη), which was blown up with air, like our foot-ball, and the *leathern ball* (κωρυκον), which was suspended from the ceiling, and stuffed with bran or sand, as those who tossed it were robust or delicate. The Romans," continued the vicar, "had also four kinds of *pilæ*, or balls. The *follis*, a large ball made of leather and blown up with air, like our foot-ball; the larger kinds of which were struck with the arm, the smaller ones, with the fist. Suetonius tells us that Augustus Cæsar greatly delighted in the amusement; and in truth it was a glorious sport, an exercise equally adapted for the young and old; or as Martial has it,—

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[*] "Not one amongst you shall depart without a gift from me." *Æn.* v. 305.

> "*Folle* decet pueros ludere, *folle* senes."[*]

"And yet," said Mr. Seymour, "neither Horace nor Virgil played at it; do not you remember the lines in the fifth Satire:

> "Lusum it Mæcenas, dormitum ego Virgiliusque;
> Namque pilâ lippis inimicum et ludere crudis."[†]

"Many thanks, Mr. Seymour, many thanks, for brushing up my recollection; but I am a little doubtful about the game at which Mæcenas played at Capua: I have, by-the-by, lately read[‡] an account of a peculiar game of ball for which the city of Sierra is celebrated, and it is supposed to be that referred to by Horace—'It is played in the foss, which has a very high wall, and it is not unlike a tennis-court; the ball is very large, and appears to be inflated with air; the arm is defended by a wooden guard or shield; at certain periods of the game, one of the players runs down a spring-board, and throwing the whole of his weight, momentum, and strength upon the ball, as it is thrown towards him, he strikes it to an astonishing distance.' The second kind of ball," continued the vicar, "was termed *trigonalis*, which is conjectured to have been nearly the same as our tennis-ball. It derived its name from the position of the three persons who played with it; they were placed in a triangle, and alternately caught and tossed the ball, and he who first let it fall to the ground was the loser. The third kind of ball was the *paganica*, as being much used in country villages. Some authors state it to have been constructed of leather and stuffed with feathers, while others conjecture it to have been a large kind of *follis*. The fourth was the *harpastum;* a small ball, so called because the gamesters endeavoured to snatch it from each other."

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[*] Lib. xiv. epig. 43.

[†] "Mæcenas goes to tennis, hurtful game
To a weak stomach, and to tender eyes,
So down to sleep with Virgil, Horace lies."—FRANCIS.

[‡] "Two Hundred and Nine Days," or "The Journal of a Traveller on the Continent," by Jefferson Hogg: London, 1827.

"It seems," observed Louisa, "to be a sport better adapted to boys than girls."

"In that supposition, you are quite mistaken," replied the vicar; "on the contrary, the hand-ball would seem to have been originally a female sport, for Homer has restricted the pastime to the princess and young maidens of Corcyra; at least, he has not mentioned its ever having been practised by the men.

"O'er the green mead, the sporting *virgins* play,
Their shining veils unbound; along the skies,
Toss'd and re-toss'd, the ball incessant flies."[*]

Mr. Seymour said that, as the vicar had satisfied them of the high antiquity of the ball, he hoped he would now afford them some information respecting its use in England.

"The game of hand-ball," said the vicar, "called by the French *palm-play*, because the exercise consisted originally in receiving the ball, and driving it back again with the *palm of the hand*, was formerly a favourite pastime among the youth of both sexes; and in many parts of the kingdom it was customary for them to play at this game during the Easter holidays for tansy cakes. In ancient times, the mayor and aldermen of Newcastle used to go in state at the feasts of Easter and Whitsuntide, to a little mall of the town to witness this game. It was originally played with the naked hand; then with a glove, which in some instances was lined; afterwards, cords and catgut strings were bound upon the hand to make the ball rebound more forcibly."

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[*] Pope's Odyssey, lib. v.

"That custom," observed Mr. Seymour, "doubtless, gave origin to the *racket*."

"It did," replied the vicar, "and the places where this game was played were called *tennis-courts*, and the game itself obtained the name of *tennis*, from the French word *tenez*[*] (take it, hold it), frequently used during the exercise. The pastime, I believe, was introduced amongst our ancestors about the year 1222, the sixth year of Henry III., by persons of superior rank and family, who erected courts or oblong edifices for the performance of the exercise."

"I long to hear something about foot-ball," exclaimed Tom.

"That is a pastime," said the vicar, "which was formerly in great vogue in England, but of late years it has fallen into disrepute. It derives its name, as you may suppose, from the circumstance of the ball being driven with the foot, in preference to the hand. When a match is made, two parties, equal in numbers, take the field, and stand between two goals, which are placed at the distance of eighty or a hundred yards from each other. The ball, which is commonly a blown bladder, cased with leather, is delivered in the midst of the ground, and the object of either party is to drive it through the goal of their opponents, by which the game is won. The abilities of the performers are best displayed in attacking and defending the goals, whence the pastime is more frequently called a *goal*, than a *game* at foot-ball. In this attack and defence, the exercise becomes exceedingly violent; the players kick each other's shins without the least ceremony; and this occasioned James I. to speak of foot-ball as '*meeter for laming than making able the users thereof*.'"

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[*] This etymology has been disputed, and it has been said that the holding or keeping possession of the ball is no part of the game; for, during the play, the ball is in continual motion, or passing from one to another. Others seek the etymology of the name, and the origin of the game, in a place in France called Tennois; or, by a change of one letter, Sennois, in the district of Champagne, where balls were first made, and the game, as it is said, first introduced.

"I believe," said Mr. Seymour, "that the ancient game of *goff* is still much practised in Scotland."

"It is," replied the vicar. "In the reign of Edward III. the Latin name *cambuca*, a crooked club, or staff, was applied to this pastime, because it was played with such an instrument. The bat was also styled a *bandy*, from its being bent; and hence the game itself is frequently called *bandy-ball*."

"And how is it played?" asked Tom.

"It is played on a smooth common, by driving forward two small hard balls, with the *bandy* I have just described, into very distant holes in the ground, about a foot deep, and nine inches over; and the party, whose ball is driven into these holes with the fewest strokes, is the victor."

"But come," said Mr. Seymour, "it is high time to think of our dinner; the children must require some refreshment. I am not, my dear vicar, one of those philosophers who believe that play was invented by the Lydians, as a remedy against hunger; nor do I subscribe to the opinion of the elder Scriblerus, that it was on such an account wisely contrived by Nature, that children who have the keenest appetites should, at the same time, be those who are most addicted to sport."

"Whether you believe or not that the Lydians invented sports shall not be a subject of contest between us," said the reverend antiquary; "but," continued he, "one thing is quite certain, that the Lydian games were at first called *Lydi* by the Romans; and afterwards, by corruption, *Ludi;* a presumption I must needs say in favour of the Lydian claim; but enough of this: to what do you propose we should next turn our attention? I doubt not you have some new sport for our recreation as well as our instruction," added the vicar.

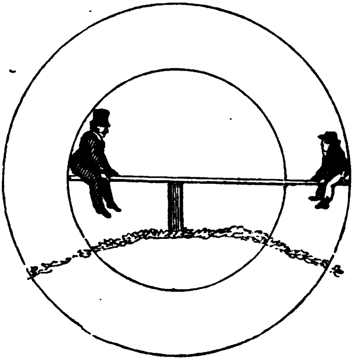
"We will, if you please, attend the children to their *see-saw,* which the gardener has lately constructed for them," said Mr. Seymour.

The party accordingly walked to the grove, in which a plank had been placed across a wooden post: and upon which Tom and John had been riding for some time in the earlier part of the morning. The boys again mounted their new hobby; and, after amusing themselves for some minutes, Mr. Seymour desired them to stop, in order that Tom might explain the principle upon which the *see-saw* acted. Tom replied, that he was not aware of any principle which could apply to riding on a plank.

"Have I not often told you, my dear boy, that the principles of Natural Philosophy may be brought to bear on the most trivial acts of life? Listen, therefore, and you shall find that your present amusement teems with instruction. You are already well acquainted with the nature and operations of the centre of gravity; tell me, therefore, whereabouts it lies in the plank upon which you are riding."

"I should think," replied Tom, "that in this instance, the centres of gravity and magnitude must coincide, or be very nearly in the same point."

"The centre of gravity must, as you say, be very nearly in the middle of the board; and if that be the case, you will allow that, supposing those who ride upon it are of equal weight, the plank must be supported in the centre, to make the two arms equal; but you and John are of unequal weight, so that you perceive the plank must be drawn a little farther over the prop to make the arms unequal; and John, who is the lightest, must be placed at the extremity of the largest arm. Thus arranged, you will exactly balance each other, and as each of you, on your descent, touches the ground with your feet, the re-action affords you a spring, which destroys the equilibrium, and enables you to oscillate in arcs about the centre of motion."



"Do we then describe the arcs of a circle as we ascend and descend?"

"Undoubtedly you must. Look at this diagram," said Mr. Seymour, "and you will see at once that the plank can only move round its centre of motion; for how could you rise, or your brother fall perpendicularly in a straight line? You must, in rising, and he, in descending, describe arcs of your respective circles. It is equally evident that his velocity must be very superior to yours; for, if you could swing quite round, you would each complete your respective circles in the same time."

"It would really appear so," said Tom; "and I have myself observed, that the lighter person has the better ride, as he moves both farther and quicker, and I now understand the reason of it; it is because being farther from the centre of motion he describes a larger arc."

"The greater velocity, with which your little brother moves, renders his momentum equal to yours. You have the most gravity, he the greatest velocity; so that, upon the whole, your momenta are equal: for you, no doubt, remember that momentum is weight multiplied into velocity.* You have here then a striking instance of mechanical advantage gained by opposing motion to matter, or velocity to weight; for I think you will readily admit, that without the aid of the plank, your little brother could never have raised you from the ground."

"That is clear enough," said Tom.

"The plank, then, thus arranged," continued his father, "constitutes what has been termed a *mechanical power*, to which the name of *lever* has been given; it is not, however, my intention at present to enter into the history of these powers, of which there are six distinct kinds; the one presented to you, in the instance of the *see-saw*, is perhaps the most simple, and not the least important of them."

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* See page 61.

"It is very curious," observed the vicar, "to reflect upon what a simple, and apparently trifling fact the powers of civilized man may be said to depend. The single truth you have just announced of making velocity a compensation for weight, has supplied his weak arm with the means of controlling the very elements."(23)

"It is very true," said Mr. Seymour, "and we might go so far as to say that, had it been the will of the Almighty Creator of the universe to have withheld from matter that property which we have been discussing, man must have remained the most helpless and forlorn of his creatures. I now propose," added Mr. Seymour, "to accompany the children to their swing; the present is a suitable opportunity for giving them some idea of the doctrine of oscillation, or the theory of the pendulum."

"Let us proceed then to the *Icarian Game*," exclaimed the vicar.

As the party walked along, Mr. Twaddleton explained the meaning of the above allusion, with which the reader will be hereafter made acquainted. The children had commenced the sport, and Mr. Seymour informed Tom and Louisa, who were attentively watching the motions of the swing, that its vibrations, like those of the pendulum of a clock, were produced by its effort to fall, from the force of gravity, and its power of ascending through an arc similar and opposite to that through which it has descended, from the momentum acquired during its descent."

"Like the bandilor, I suppose," said Louisa.

"Exactly, my dear, that is a very good comparison; for as the bandilor, having descended along the string by its gravity, acquires such a momentum as to enable it to ascend the same string, and thus, as it were, to wind itself up; so does the pendulum or swing, during its descent, acquire a force that carries it up in an opposite arc to an equal height as that from which it had fallen. But tell me, Tom, whether you have not discovered that the motion of your new swing differs from that which you experienced in your former one?"

"The ropes of our present swing are so much longer than those which we formerly used, that the motion is much pleasanter."

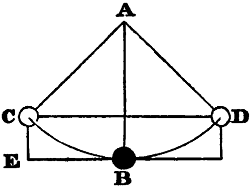
"Is that all?" said Mr. Seymour. "Have you not observed that you also swing much slower?"

"I have certainly noticed that," said Tom.

"It is a law which I am desirous of impressing upon your memory, that the shorter the pendulum, or swing, the quicker are its motions, and *vice versa;* indeed, there is an established proportion between the velocity and the length, which I shall, hereafter, endeavour to explain to you. Galileo, the celebrated philosopher, and mathematician to the Duke of Florence, accordingly proposed a method of ascertaining the height of the arched ceiling of a church by the vibrations of a lamp suspended from it. The solution of the problem was founded on the law to which I have just alluded, viz. that *the squares of the times of the vibrations are as the lengths;* so that a pendulous body, four times the length of another, performs vibrations which last twice as long. Now it is known that, in the latitude of London, a pendulum, if 39 inches and two tenths in length, will vibrate seconds, or make 60 swings in a minute; by observing, therefore, how much the pendulous body deviates from this standard, we may, by the application of the above rule, find its length; if the distance from the bottom of the lamp to the pavement be then measured, which may be done by means of a stick, and added to the former result, the sum will give the height of the arch above the pavement: but I will show you the experiment the next time we go into Overton church; the vicar can tell us the exact height of the roof, and I will try how nearly I can approach the truth, by observing with a stop-watch how many seconds one vibration of the chandelier continues."

"But, papa, why surely the duration of its vibration must depend upon the force which you may happen to give to the chandelier?"

"Not in the least; and this brings us at once to the consideration of the most curious and important fact in the history of the pendulum, and for a knowledge of which, we are also indebted to Galileo.* It is termed its *isochronous*† property, or that by which all its vibrations, whether great or small, are performed in exactly the same period of time; but that you may be better able to comprehend this subject attend to the diagram which I have prepared for your instruction. Suppose that the swing or pendulum A B be raised to C, it will, in effect, be raised the perpendicular height E C, and in falling will describe the arc C B; and, in the point B, it will have that velocity which is acquired by descending through C B, or by a body falling freely through the perpendi-



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* This discovery was published at Paris, in a treatise called "*L'Usage du Cadran ou de l'Horloge Physique Universelle,*" in the year, 1639; from which may be dated the invention of the pendulum.

† Compounded of the Greek words *ισος* equal, and *χρονος* time.

cular C E. This velocity will be sufficient to cause it to ascend through an equal arc B D, to the same height from whence it fell at C; and since the times of ascent and descent are equal, it will describe both these arcs in exactly the same space of time. Having lost all its motion at D, it will again begin to descend by its own gravity; and in the lowest point B it will acquire the same velocity as before, which will cause it to reascend to C; and thus, by ascending and descending, it will perform continual vibrations in the circumference C B D; and, were it not for the resistance of the air, and the friction at the centre of motion A, the vibrations would never cease: but from these obstructions, though small, it happens, that the velocity of the mass of matter at B is a little diminished in every vibration; and consequently it does not return precisely to the same points C or D, but the arcs described continually become shorter and shorter, till at length they grow insensible; and yet the very same time is required for the performance of the shorter as the longer arcs; for, although in the one case the body passes over less space, still its velocity is proportionally decreased. You perceive, then, that in an attempt to ascertain the height of a ceiling by the vibrations of the chandelier, the extent of its swing cannot alter the time which may be required for its completion. And, if you will place your little brother in the swing, you will perceive that he will return to your hand, in nearly the same space of time, whether he describes a large or small arc; although this experiment must be considered as extremely rude, since there are many disturbing causes for which the theory cannot possibly make any allowance. I must, moreover, warn you that where the arc described is very considerable, the difference in the time will be greater; for, in order to ensure this property of vibrating through unequal arcs in equal times, it is necessary that the path of the body should describe a peculiar curve, called a cycloid (24), and not the segment of a circle; at present, however, it is not possible for us to enter into this difficult branch of science, although I trust that at some future period, I shall be justified in an attempt to explain it."

Mr. Seymour having concluded his lecture, was about to return to the lodge, when Mrs. Seymour approached the party, carrying in her hands a letter, which the smile on her countenance announced to contain agreeable intelligence.

"I have just received," said Mrs. Seymour, "a letter from Miss Villers, whom you must all remember as a most delightful person. I am informed that she is about to be married to the nephew of a gentleman who is at present in our neighbourhood in search of a country residence."

"Does she mention the gentleman's name?" inquired the vicar.

"Mr. Henry Beacham," said Mrs. Seymour.

"The nephew of Major Snapwell, I declare," exclaimed the delighted vicar.

The whole party participated in the pleasure which their excellent friend expressed at this discovery, and Mr. Seymour immediately accompanied Mr. Twaddleton to Ivy Lodge, to congratulate the major, and to make such arrangements as might expedite the purchase of Osterley Park, and the consequent introduction of a family into the neighbourhood of Overton, from whose society the Seymours anticipated the highest satisfaction.

At the same time Mrs. Seymour hastened to dispatch a letter to Miss Villers, in order to solicit her immediate presence at Overton Lodge.

## CHAPTER X.

MARBLES.—ANTIQUITY OF THE GAME.—METHOD OF MANUFACTURING THEM. — RING-TAW. — MR. SEYMOUR, THE VICAR, AND TOM, ENTER THE LISTS.—THE DEFEAT OF THE TWO FORMER COMBATANTS; THE TRIUMPH OF THE LATTER. — A PHILOSOPHICAL EXPLANATION OF THE SEVERAL MOVEMENTS. —THE SUBJECT OF REFLECTED MOTION ILLUSTRATED.—THE VICAR'S APOLOGY, OF WHICH MANY GRAVE PERSONAGES WILL APPROVE.

In our last chapter we left Mr. Seymour and his reverend friend on their way to Ivy Cottage; it is only necessary to state that the major received them with that satisfaction and gratitude which the nature of their visit could not fail to produce. Plans were proposed, and arrangements concluded for the furtherance of the object we have announced; in short, in the brief space of an hour, the major had determined the course of his future life, and had framed schemes of happiness, and visions of domestic peace, which he impatiently sought to realize. The vicar was detained by the major, but Mr. Seymour quitted Ivy Lodge and returned to his family. He found the children engaged in playing at marbles. Tom was displaying to his sisters many instances of his adroitness and skill in shooting at and hitting marbles.

"Why, Tom!" exclaimed Mr. Seymour, "how came you possessed of such a multitude of marbles?"

"By luck; good luck, papa; I won them all before the holidays; and I can assure you that my schoolfellows acknowledge me as one of the best players at *ring-taw* in the school."

"Justly then, has your merit been rewarded," said the father. "Have you not read of the skilful Roman, who could blow peas through a quill, and deposit them with such nicety on the point of a pin, placed at some distance, as rarely to miss his aim?"

"And what was his reward?" asked Tom.

"A bushel of peas, my boy, which the emperor commanded to be presented to him. But do not misunderstand me, far be it from my wish to disparage your skill; whatever we undertake, we should endeavour to accomplish; I am, therefore, well pleased to find that you can play at marbles with so much success."

"I wonder, who invented marbles?" said Tom.

"That question, my dear, must be addressed to Mr. Twaddleton, who, I have no doubt, will immediately answer it."

Scarcely had these words been spoken, when the vicar appeared on the lawn. Mr. Seymour informed him of the subject of their conversation, and added, that he had just told the children he was sure he would readily answer their question.

"Not so readily as you may imagine," replied the vicar; "but I will tell you all I know upon the subject. It appears to be a very ancient game; for it is stated by Suetonius, that Augustus, when a youth, spent many hours in the day in playing, with little Moorish boys, '*cum nucibus*,' that is, *with nuts*, which appear to have been then used in the very way in which you now play with your marbles. In later times, round stones picked out of gravel, were introduced for this purpose. The marbles which you now hold in your hand are substitutes of still more modern invention. The best of them are imported from Holland, where, as I have been informed, they are manufactured, by grinding fragments of alabaster and of other stones, in an iron mill of a peculiar construction, in which there are several partitions furnished with rasps, which turn with great velocity, by means of a stream of water; and thus having rounded the stones, project them out of different holes for which their size may adapt them. Thus manufactured, they are brought down the Rhine, and from thence dispersed throughout Europe; immense quantities are also exported to India and China. There are, however, as you well know, inferior kinds, which are of home manufacture, and consist of potter's clay covered with a glaze, and burnt in a furnace."

"I have often wondered what is the meaning of the words *taw* and *ally*," observed Tom.

"Why, your *taw* is a brown marble, and your *ally*, if I remember rightly, a very white one; is it not so?" asked the vicar.

"To be sure," said Tom.

"Very well then," said the vicar, "the words are clearly abbreviations of *tawny* and *alabaster*."

"Now then," said Mr. Seymour, "for a game; what is it to be, Tom?"

"*Ring-taw* for ever," cried Tom; "it is the only game of marbles worthy of being played."

"It is really so long since I left school," observed his father, "that I must beg you to refresh my memory, and give me some instructions about this favourite game of yours."

"I will tell you all about it. We must first draw a circle, on which each player is to put a certain number of marbles to be previously agreed upon; we then make a mark at some distance, which is called the *offing*, and from which we are to shoot at the marbles in the ring."

"That is all very intelligible," observed his father; "and I suppose the object of the player is to shoot a marble out of the ring, which not only gives him that marble, but entitles him to shoot again at another, and so on, until he misses, or all the marbles are won."

"That is right, papa."

"And a good marksman," observed the vicar, "who has the first shot, may easily win the game, before any other player can gain the opportunity of shooting at a single marble."

"I see that clearly," said Mr. Seymour; "he may strike out a marble from the circle, and then shoot at another, and in this manner traverse the whole ring; I therefore conclude, that good players will always demand a large ring, or else there would not be much chance for any one, except for him who played first."

"That is the game; but I must tell you," said Tom, "that if the player should leave his own marble in the ring, he is at once put out; and should it be within a certain distance on the outside, an adversary may shoot at it, and by hitting it, put him also out of the game."

"I believe that I am now a perfect master of the subject," said Mr. Seymour; "what say you, vicar?"

"I understand it; and it appears to me to be capable of some scientific calculation; but the practical results must, of course, differ very widely from the theory, for the unevenness of the ground, and the inaccurate construction of the marble, are circumstances which never can be duly estimated.

"Certainly not," replied Mr. Seymour; "these difficulties even exist at the game of billiards, where the table is smooth and perfectly horizontal: but we do not require perfect accuracy, an approximation to it will be sufficient for the purposes of illustration; we will, therefore, if you please, proceed at once to the game, and I will endeavour to point out to Tom the nature and direction of the several forces by which each marble will be influenced."

Tom, accordingly, like the son of Cornelius Scriblerus, converted his legs into a pair of compasses, and described, with the toe of his shoe, the necessary circle upon the ground. Each party, by agreement, placed two marbles upon the ring, and it fell to the lot of the vicar to open the campaign Mr. Twaddleton then advanced, and with the assumed air of a true knight-errant, approached the ring, exclaiming with a loud voice, and with a gesture of inexpressible drollery, "I demand gracious leave that I may be delivered of my vow, and forthwith combat in the lists;" so saying, he unfurled his red banner, and sounded a trumpet; or in more humble phraseology, he extracted his handkerchief from his pocket, and applying it to his nasal organs, produced a loud and thrilling blast, which frightened every sparrow from its resting-place. After this preliminary ceremonial, he marshalled his limbs into the most appropriate attitude, and thrusting one hand behind the exuberant tail of his coat, he, with the other, shot forth his missile at the largest marble opposite to him. His *taw* faithfully delivered its errand, and inflicted such a blow upon the paunch of his antagonist, that although nearly twice the size of its assailant, like a true bully, it skulked off, and retreated several feet beyond the lists; but, alas! the little marble of the vicar, unlucky wight! was so stunned by the operation, that it staggered, and reeled backwards into the ring, and thus, according to the established law of the field, completed by one act the total defeat of its luckless commander.

"Your marble is left in the ring!" exclaimed Tom, with a shout of triumph.

"I see how it happened," said Mr. Seymour; "the vicar struck the marble plump, or 'played a full ball,' as we say at billiards, and the result easily admits of explanation. You already know that a marble possesses elasticity; when, therefore, the one in the ring was struck, it went off with a velocity equal to that with which the striking marble approached it, while the latter, in return, received a blow equal to that it gave, which destroyed its motion. When we go back into the library, I will exhibit a very pretty experiment in farther elucidation of this philosophical truth." (25)

It was now Mr. Seymour's turn to enter the lists. He carefully applied his knuckles to the ground and taking aim at a little marble which he had selected as his victim, gallantly shot the missile from his thumb and finger; but, alas! alas! the goddess, whatever may be her name, who presides over this species of tournay, doubtless saw the impending fate of her favourite, and, after the example of Venus, who turned aside the weapon from Æneas, assumed the shape of a small pebble, and thus arrested the fatal course of the marble, and gave it a new direction, which sent it curveting through the ring, without committing one single act of devastation.

"Bravo! bravo!" exclaimed Tom, "it is now my turn."

The boy, according to the usage of the field, might at once have won the game by striking his father's marble; but he was too magnanimous to take such an advantage, and too eager to display his own skill, to cut the game short by a manœuvre: he had determined to win his laurels by hard fighting and generalship. He, accordingly, proceeded to strike a ring marble; in effecting which he had, like the vicar, challenged a *gigantic knight* as his antagonist; but, instead of striking it *plump*, he struck its upper quarter, so that it was rolled out of the ring, while the striking marble, imparting only a portion of its momentum, continued to move forward after the impact. This course was greeted with the acclamations of Mr. Seymour and the vicar, the latter of whom declared it to have been "nobly run," and gallantly accomplished; and extracting a sixpence from his waistcoat pocket, exclaimed, after the manner of chivalry, "*Largesse, largesse*, glory to the sons of the brave! glory to the invincible knight of the taw!"

The boy had not only struck the marble out of the ring, but he had, at the same time, contrived to place his own marble in the most favourable position for his future operations; and, indeed, it may be here observed, that in this consists the art of playing the game. It is almost unnecessary to add that Tom won every marble in succession.

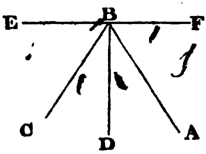
Mr. Seymour then proceeded to explain the laws of impact, by which the movement of each marble was directed. He observed, that the subject embraced two propositions, viz. the direction of the *object* marble, after having been struck, and that of the *striking* marble, after the stroke. He said that, if a straight line were drawn between the centres of the striking and object marbles, it would necessarily pass through their point of contact, and, if continued, would represent the path of the latter after the blow. In order to find the direction of the *striking* marble, after the shock, he told him that he must imagine a tangent to the path of the *object* ball drawn from its centre, and then a line parallel to it, from the centre of the striking marble; the latter of which would be the required path.

Mr. Seymour now inquired whether there was any other game of marbles at which they could amuse themselves.

" The game which we call " *lagging out*," replied the boy, " is amusing enough. It consists in striking your marble against the wall, and making it rebound, so as to hit any other marble that is placed at a certain distance from it, or to come within a span of it."

" I understand," said his father, and, like *ring-taw*, it may be made subservient to our purpose of illustrating the doctrine of forces; although I think that the principle of *reflected motion* may be more readily explained by the rebounding ball."

Mr. Seymour here took the elastic ball, and threw it obliquely against the wall, from which it rebounded in an opposite and equally oblique direction. He then sketched the annexed figure, and proceeded as follows:—



" When I threw the ball against the wall B, in the direction A B, having struck it, it glanced off, making an angle, in its passage back again, equal to that which it made in its approach to the wall. If I draw the perpendicular B D, this fact will be rendered more apparent, and you will perceive that the angle A B D is equal to the angle C B D: the former is termed the *angle of incidence*, the latter the *angle of reflection;* and these angles, remember, are always equal, provided the ball under experiment be perfectly elastic."

"Do you mean to say," asked Tom, "that the more obliquely I throw the ball against the wall, the more obliquely it will rebound?"

"Exactly; that is my meaning: and see whether you cannot explain the fact, for it depends on the composition and resolution of the forces, a subject which I should hope you thoroughly understand."

Tom pondered for some time over the drawing, and at length observed, that there was one difficulty which he could not immediately surmount.

"State your difficulty," said Mr. Seymour.

He proceeded to observe, that the force acting in the direction A B would certainly be resolved into two others, viz. one in the direction F B, and another in that of D B; "because," continued he, "these lines are the adjacent sides of the parallelogram, of which A B is the diagonal; and I well know that whenever a force strikes obliquely, it is thus resolved."

"That is all very well explained," replied his father; "pray proceed."

"Now comes the difficulty," continued Tom; "for the force D B will of course be destroyed by the wall, and that represented by F B, which is the only one that can remain, would carry the ball to E."

"It certainly would do so," answered his father, "if the ball were perfectly devoid of elasticity;

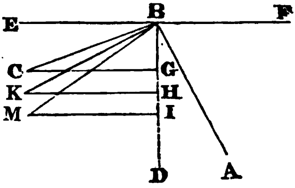
but remember that, in consequence of this property, the force D B will be exchanged for one in an opposite direction, B D.

"I had entirely overlooked the elasticity," said Tom; "I now see my way clearly, for in that case there must be two forces acting in the directions B D, B E, which will, of course, drive the ball down the diagonal B C."

"Your demonstration is perfectly correct, my boy; and I think you will now admit that I could not have adduced a more beautiful instance of the composition and resolution of forces; for, in the first place, you resolve the diagonal force into two others, and then you recompound these again to produce another diagonal one."

"But I think you told us that the angles of incidence and reflection were only equal when the rebounding body was perfectly elastic."

"Clearly so; the force D B must be exchanged for an equal one B D, or else the angle A B D cannot be equal to the angle D B C; but I will render this fact still farther intelligible by another diagram. Let B, as in the former case, represent the wall, upon which the imperfectly elastic body impinges in the direction A B. —The force will of course be resolved into two others, viz. into D B and F B; the force D B, however, instead of being replaced by the opposite one B D, will now be represented by the shorter line B G; or that of B H or B I, according to the degree of elasticity. If we, therefore, complete the parallelogram, B C, B K, or B M will be the diagonal path of the body; making, as you perceive, the *angle of reflection* D B C, greater than that of *inci-*



*dence* A B D; and where the body is perfectly inelastic, the force D B will be wholly destroyed, and, the force B E alone surviving, the body will be carried along the line B E. I have now," continued Mr. Seymour, "explained to you the principal laws which govern those forces by which your ball or marbles are actuated. It is true that in practice you cannot expect the results should accurately coincide with the theory, because, in the first place, you cannot obtain marbles that are of equal density and elasticity, and of true figure; and, in the next, there will be obstacles against which it is impossible to guard. The spinning of the marble will also have a material influence on its motion, as we have already discovered. In the game of billiards, where every obstacle is removed, as far as art can assist, the theory and practice are often strangely discordant. But we have dwelt sufficiently upon the subject; we will, therefore, return to the library, where I intend to exhibit an experiment in farther elucidation of the subject of collision."

The party accordingly proceeded on their return.

"I hope," said Mr. Seymour, addressing himself to Mr. Twaddleton, who was walking a few paces before him, "that the maiden ladies have not espied their vicar at a game of marbles; if they should, what a chuckling would there be at their next tea-party!"

"A fig for the spinsters," exclaimed the vicar, as he hastily turned round, and arrested the progress of the party by his gesture. "You really speak, Mr. Seymour, as though it were derogatory to my character to descend from the more austere pursuits to the simple but innocent amusements of youth. Let me remind you, sir, that the Persian ambassadors found Agesilaus, the Lacedæmonian monarch, riding on a stick.'

"True," replied Mr. Seymour; "and the ambassadors found Henry the Fourth playing on the carpet with his children; and it is said, that Domitian, after he had possessed himself of the Roman empire, amused himself by catching flies; but these were kings: now I admit that philosophers are monarchs, but monarchs are not always philosophers; you must, therefore, produce some less objectionable authority, if you stand in need of such a sanction. Let me see whether I cannot assist you; there was Socrates, if tradition speaks truly, who was partial to the recreation of riding on a wooden horse, for which, as Valerius Maximus tells us, his pupil Alcibiades laughed at him."

"I care not who laughs at me," exclaimed the vicar; "I enjoy the amusements of youth, and agree with Dr. Paley, in regarding the pleasure which they are made to afford, as a striking instance of the beneficence of the Deity; and should you so far relax as to put your plan into execution, of writing a work upon juvenile sports, I hope you will call upon me to compose a eulogy, by way of preface."

"I shall not forget your offer, depend upon it."

"Did not Archytas," resumed the vicar,

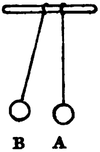
> 'He who would scan the earth, and ocean's bound,
> And tell the countless sands that strew the shore,'

as Horace says, invent the children's rattle?—Toys, my dear sir, have served to unbend the wise, to occupy the idle, to exercise the sedentary, to moralize the dissipated,"—

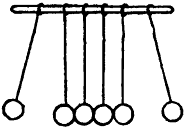
"And," interrupted Mr. Seymour, "to instruct the ignorant."

"I will also convince you," continued the vicar, that the tournaments were indebted for their origin to the Troy game (*ludus Trojæ*), first introduced into Italy by young Ascanius."

The foregoing episode having been concluded, the party proceeded, without any farther interruption, to the lodge. On their arrival, Mr. Seymour produced a piece of apparatus, for the purpose of exhibiting the experiment he had promised, in illustration of the doctrine of the Collision of Elastic Bodies.

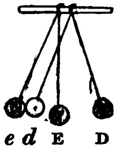


"Here are two ivory balls," said he, "suspended by threads; I shall draw one of them, A, a little on one side; now I let it go, it strikes, you see, against the other ball, B, and drives it off to a distance equal to that through which the first ball fell; but the motion of A is stopped, because, when it struck B, it received in return a blow equal to that it gave, and its motion was consequently destroyed. To extend the experiment, here are six ivory balls hanging in a row; I will draw the first out of the perpendicular, and let it fall against the second; see! see! none of the balls appear to move, except the last, which you perceive flies off as far as the first ball fell. I should like to hear you explain this."



"Tom observed, that when the first ball struck the second, it received a blow, in return, which destroyed its motion; and that the second ball, although it did not appear to move, must have struck against the third, the reaction of which set it at rest; that the action of the third ball must have been destroyed by the reaction of the fourth, and so on, until motion was communicated to the last ball, which not being reacted upon flew off."

Mr. Seymour commended Tom for his explanation; but he begged him to understand that such an effect only occurred when the balls were elastic; and he proceeded to exhibit the difference between elastic and inelastic bodies by another experiment. "When you raise one of these inelastic balls, made of clay, out of the perpendicular, and let it fall against the other, E, the action and reaction not being augmented by the force of elasticity, are insufficient to destroy the motion of the former; only part of the motion D will, therefore, be communicated to E, and the two balls will move together to *d e*, which are less distant from the vertical line than the ball D was before it fell."



Before we close this chapter, we cannot resist the pleasure of informing our readers that Major Snapwell, in company with his legal adviser, had quitted Overton, for the purpose of making such preliminary arrangements as the purchase of an estate must necessarily require. It is not our intention to accompany them; nor shall we travel over the plains of parchment, nor wade through the rivers of ink, which separate the confines of verbal agreement and legal possession; but claiming the prerogative of authors, we shall dip our wing in the cup of inspiration, and by a single flourish of our feathered talisman, at once put the worthy Major in the undisturbed possession of his newly-purchased mansion, and instal him in one of Daw's most comfortable elbow-chairs, surrounded by all the luxuries of polished life.

## CHAPTER XI.

MR. SEYMOUR AND HIS FAMILY VISIT THE MAJOR AT OSTERLEY PARK.—A CONTROVERSY BETWEEN THE VICAR AND THE MAJOR.—THE SUCKER.—COHESIVE ATTRACTION.—PRESSURE OF THE ATMOSPHERE.—MEANING OF THE TERM SUCTION.—CERTAIN ANIMALS ATTACH THEMSELVES TO ROCKS BY A CONTRIVANCE ANALOGOUS TO THE SUCKER.—THE LIMPET.—THE WALRUS.—LOCOMOTIVE ORGANS OF THE HOUSE-FLY.—A TERRIBLE ACCIDENT.—A SCENE IN THE VILLAGE, IN WHICH DR. DOSEALL FIGURES AS A PRINCIPAL PERFORMER.—THE VICAR'S SENSIBLE REMONSTRANCE.—THE DENSITY OF THE ATMOSPHERE AT DIFFERENT ALTITUDES.—THE POP-GUN.—THE AIR-GUN.—AN ANTIQUARIAN DISCUSSION, IN WHICH THE VICAR AND MAJOR SNAPWELL GREATLY DISTINGUISH THEMSELVES.

In the course of the ensuing week, Mr. and Mrs. Seymour proceeded to offer their congratulations to the new proprietor of Osterley Park. On being ushered into the library, they were not a little surprised and startled by the loud voice of the major, who addressing Mr. Twaddleton, exclaimed, "Never will I again suspect the antiquity of your rarities, nor question the rarity of your antiquities."

"Mr. and Mrs. Seymour," said the major, "welcome to Osterley Park. You find me, as usual, engaged with our friend in a learned controversy, and I begin to fear that my warmth may have offended him."

"Offended me!" exclaimed the vicar, "oh no. No, indeed, my dear Major Snapwell; a difference of opinion on an antiquarian subject may excite my regret, and in some cases, as in the present instance, awaken my pity; but it cannot offend me; it can never occasion any feeling like anger: that would be to visit the folly of others upon myself."

"What is the subject of your difference, gentlemen?" asked Mr. Seymour.

"The evidences of druidical rites, as deducible from certain cavities to be found in granitic rocks, and which have received the appellation of *rock basins*," replied the major.

"And of which," exclaimed Mr. Twaddleton, "I have a most unquestionable specimen, collected by no less a geologist than the curator of the cabinet at Penzance, from that ancient metropolis of the druids, *Carn-bre hill*."

"I admit," said the major, "that I never before saw so perfect a specimen; it is as spheroidal internally, as if it had been actually shaped by a turning-lathe."

"And yet, in spite of such evidence," replied the vicar, "you question its sacred origin, and deny its ever having been used as a pool of lustration."

Mr. Seymour here interposed. "Upon a subject of purely historical difficulty, I might feel diffident in offering myself as an umpire between such learned antiquaries; but, as the origin of 'rock basins' involves a geological question, I will venture to deliver an opinion. Depend upon it, vicar, that you are maintaining a position that cannot be defended; these uncouth cavities, together with all the fancied statuary of Borlase, (26) have never been shaped by any chisel but the tooth of time, nor have any artists, but the elements, been engaged in their formation."

"What say you to that, vicar?" triumphantly exclaimed the major.

"Oh, impiety, impiety!" cried the vicar;—

> 'Hostis habet muros, ruit alto à culmine Troja,'

as Maro has it. That such glorious monuments, which have so long braved the tempests, should fall under the hammer of these Philistines! Geology, Mr. Seymour, is infidelity in masquerade; remember the mites in the Cheshire cheese, Mr. Seymour, 'consider their ways and be wise.'"

"Philistines, as we are, in your opinion," replied his opponent, "our forges have served to sharpen your weapons against the attacks of infidelity."

"Come, come, gentlemen," said Mr. Seymour, "the continuance of this discussion can neither amuse nor instruct us. I have, however, some intelligence to communicate which will soothe every feeling of irritation. We have received a letter from Isabella Villers, in answer to an invitation to Overton, and she graciously accepts it, and proposes being with us on Wednesday next.

The major was delighted, and conversed upon various points connected with the intended union of his nephew with that lady, which we do not think it necessary to relate in this place. The vicar and major shook hands, and it was proposed that they should dine at Overton Lodge the following day, and, as a specific overture, that the major should visit the vicarage in his way, and again inspect some of the disputed antiquities of the reverend collector.

The following morning was occupied with the consideration of those different toys which are indebted for their operation to the pressure of the atmosphere.

"Tom," said Mr. Seymour, "fetch hither your leathern sucker."

"John is, at this moment, amusing himself in the garden with the one which I brought with me from school," replied Tom.

"Then you shall construct another for yourself. Here is leather and string."

"This leather is too stiff; but I may, perhaps, make it answer the purpose by first soaking it."

Having allowed it to remain in water for a short time, the leather became sufficiently pliable for his purpose; he therefore cut it into a circular shape, and affixed a string through its centre. The juvenile party now hastened to the lawn, and having once again dipped his newly-constructed sucker into the water, the ingenious boy placed it upon a stone, pressed down the leather with his foot, and succeeded in making it raise the weight.

"Well done, my boy. Now, then, explain the reason of the leather's adhesion to the surface, and of its being thus capable of retaining its hold, notwithstanding the gravity of the stone."

"In the first place," answered Tom, "the edges of the wet leather, from being closely pressed, stuck with sufficient firmness to the smooth surface of the stone, to resist the force of the string, as I pulled it upwards; the consequence was, that a hollow was formed in the middle part of the leather; and, as that hollow place cannot contain any air, it is called a *vacuum*."

"Very well," replied his father, "so far you are right; but you have not informed me in what man-

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ner a *vacuum* acts, in preventing the stone from quitting the leather."

"It makes it adhere to it by some kind of *suction*, but I confess that I do not exactly understand the subject."

"Then let us proceed cautiously and deliberately in the explanation. In the first place, you have said, and said correctly, that the edges of the leather adhere to the stone; but what is the nature of the power to which this adhesion is to be referred? I perceive you are puzzled by the question: attend, then, to my explanation: you must know that there exists a tendency in all bodies to adhere together, provided the contact of their surfaces be sufficiently perfect; this property is termed *cohesion*, or cohesive attraction, from the Latin word *cohæreo*, which I need not inform you signifies to *stick together*. The dry leather will not adhere to a smooth surface, because, in that case, the contact cannot be rendered sufficiently perfect; but, when saturated with water, the interstices of the leather are filled with that fluid, and the inequalities of the surface, which must always prevent close contact, are removed. If two bodies, when placed together, be not sufficiently smooth, or polished, it will be vain to make any attempt to produce their cohesion; since the particles will, in such a state, touch each other only in a few points; it is for this reason that carpenters, when they intend to glue pieces of wood together, plane the surfaces perfectly smooth, before they apply the glue."

Tom here acknowledged that he had not before understood the reason of the leather's adhesion to the stone.

"Having then settled this point to your satisfaction," continued Mr. Seymour, "let us proceed. Your idea of a *vacuum* being formed in the hollow part of the leather is perfectly correct: for, as you draw up the central part by the string, the hollow thus produced must necessarily be a *vacuum*, since the air cannot pass through the leather to supply it; in this state, therefore, the atmosphere presses upon the exterior of the leather, and like any other weight prevents its rising from the stone."

Fanny and Louisa here expressed some surprise on hearing of the weight of the atmosphere; the former observed, that she did not feel any pressure from it. Their father explained the reason of their not being conscious of the weight, by informing them that their bodies contained air, which, by its elasticity, counteracted the pressure from without; but that, if it were possible to remove all the air which the body contained, the pressure of the atmosphere would not be counteracted; and the consequence would be, that we should be flattened like a pancake by its weight, which had been ascertained by experiment to be equal to fifteen pounds upon every square inch of surface, or, as much as forty thousand pounds upon the body of a man of ordinary size.

"Until your explanation," said Tom, "I really believed that the leather adhered to the stone by some kind of *suction*, just as the back of my hand adheres to my lips, whenever I place it to my mouth, and draw in my breath."

Mr. Seymour here expressed a doubt whether his son was even yet a perfect master of the subject: he told him that there was no such operation in nature as *suction;* that it was merely a popular term to denote the action of the air upon a vacuum. "Your hand," said he, "adheres to your mouth, in consequence of your forming a vacuum within it, by forcibly drawing in your breath, and the resistance which is opposed to its removal, arises entirely from the pressure of the atmosphere upon it. Many are the effects which may be explained upon a similar principle. I dare say you well remember the astonishment which you expressed at the force with which the limpets attached themselves to the rocks."

"O yes, papa," exclaimed Louisa, "I well remember, when we walked on the sea-shore, that, on first touching the limpets, they appeared loose and moveable, but before I had time to remove them, they fastened themselves as firmly, as though they had been a part of the rock upon which they were fixed; how could that happen?"

Mr. Seymour replied that these sea-insects possessed the power of converting their whole bodies into *suckers;* and he informed them, that many other animals were endowed with a similar faculty. He instanced the claws of the polypus, which are furnished with many such suckers, by means of which the animal is enabled to hold to whatever it attaches itself with very considerable force.

"Have you never observed," asked Mr. Seymour, "the security and ease with which flies frequently walk upon a smooth wall, or a pane of glass, or even along the ceiling, with their bodies downward?"

"To be sure," replied Tom; "but are not their legs provided with some sticky matter, which enables them to preserve themselves from falling?"

"That is a popular error, my dear; the fact is, that their feet are provided with little cups, or suckers, which they alternately exhaust and fill with air; by which means they are enabled to walk in every position, over the most slippery surfaces. (27) In like manner, the walrus, or seal, a painting of which you may remember to have seen in the Panorama of Spitzbergen, is capable of climbing the masses of slippery ice with perfect security."

At this moment, Tom's stone fell from the sucker. Louisa enquired how it could have happened.

"The circumstance is to be easily explained," said her father. "The atmosphere, by its pressure, ultimately forced its way through the edges of the sucker; its interior, therefore, became filled with air, and it consequently balanced the external weight, which had before confined it."

"I think," said the vicar, "that Tom must now surely understand the theory of the leathern sucker; what say you, my boy? Cannot you exclaim with Persius, '*Intus* et in *cute* novi.'"

"Which I suppose," observed Mr. Seymour, "you would construe, 'Well do I know the nature of the *cavity*, and the operation of the *leather*.'"

"Exactly," answered the vicar.

"Then never more protest against the vice of punning, for a more atrocious specimen of the *lusus verborum* was never sported by the most incorrigible Johnian: but, to your classical fancy, any object enclosed in a Latin shrine appears as a deity."

The vicar had just drawn up his person into a suitable attitude for combat, and would, no doubt, have defended himself against this unexpected attack with his usual address, had not a circumstance occurred, which put an abrupt termination to the discourse.

"See! see!" exclaimed Louisa; "what can have happened? There is Jerry Styles, with a crowd of villagers, running towards us in the greatest state of agitation and alarm."

"Jerry Styles? It is, indeed, as you say, my faithful clerk," cried the vicar. "Bless me,—bless me, what can have happened! Is the vicarage on fire? Has the old roof at last tumbled into the chancel?"

"Oh, sir! — oh, my dear sir!" vociferated the terrified servant of the church, whose blanched cheeks made his red nose appear like a volcano burning amidst a desert of snows, "poor Tom Plank has blown the roof off his house, and is so dreadfully wounded that it is impossible for him to survive long, if, indeed, he is not already dead."

"How did it happen?" exclaimed several voices.

"From a *speriment!* a *speriment!* it all came from a *flossical speriment!*" replied the breathless clerk; "but, pray, gentlemen, come directly to the village; for mercy's sake, gentlemen, don't delay a moment."

The vicar and Mr. Seymour instantly proceeded with the terrified Jerry Styles towards the house of the unfortunate "planer of deals;" they had not gone far, before they met several other villagers, who informed them that Dr. Doseall was in attendance upon the wounded man, and had pronounced him to be in the greatest danger.

On their arrival at the house, the roof of which they at once perceived had not suffered in the fray, they learned that Tom Plank had been engaged in some experiments for producing a *vacuum*, in the prosecution of his new scheme of propelling passengers through a funnel; and that in firing a mixture of oxygen and hydrogen gases, he had neglected the usual precaution, and blown up his apparatus; the stop-cock had been unceremoniously expelled through the window, and, in its passage, had ungraciously flown in the face of its master, and left the traces of its indignation in the form of a very slight scratch upon his forehead; this accident, with a burn of the fingers, was the only personal injury he had sustained.

"Come, come," said Mr. Seymour, "no mischief has occurred, and the accident will, I trust, teach you more caution for the future. You are not the first adventurer who has *burned* his *fingers* by *bubble* speculations, and in vain attempts to *raise the wind.*"

Dr. Doseall, however, with a countenance of stern composure, and a portentous shake of the head, maintained that the accident was by no means so trifling as Mr. Seymour appeared to suppose; and, in conformity with this view of the case, he had prudently bled his patient largely, and directed sundry mixtures and lotions, together with a *quantum sufficit* of laudanum, in order, as he said, "to keep down the swelling and puffing of the head," although there were those present who were uncharitable enough to hint, that the *swelling* and *puffing* related rather to the Doctor's bill and character, than to the patient's pericranium.

After a short interval, engaged in answering the numerous enquiries of the anxious spectators, the doctor, with an air of awful solemnity, advanced to the sufferer, and offered him a bolus of no ordinary size; upon the virtues of which he descanted in most touching language.

"Avaunt!" exclaimed Mr. Seymour, "do you suppose that Tom Plank has the throat of the great dragon which the Indians believe to swallow the moon, and thus to produce the phænomena of lunar eclipses? Away with thy treacle and pipe-clay; there cannot be the least pretext for this parade of remedies; I warrant you that Dame Nature, unless she be put out of humour by your officious interference, will heal the scratch before to-morrow's sun-rise."

The doctor, as our readers will readily imagine, was very justly incensed at this ex-professional interference. His first determination was to treat the matter as a joke, and to turn the laugh against the unmannerly intruder; but the abortive smile was strangled in its birth, and suffused the hue of death over his visage. Never did a countenance, in the focus of his blue window bottle, by candle-light, exhibit a more ghastly pallor; and we can scarcely predict what might have been the consequence, had he not instantly administered a consoling cordial to his nostrils; for, be it known, that the doctor took snuff in the same extravagant proportion as his patients took physic. Having by these means recovered his self-possession, he instantly seized his cane, and waving it with as much dignity, as Jove is said to brandish his thunder, he departed in deep dudgeon, which was betrayed by a snarl, not unlike that of a hungry dog who is unexpectedly despoiled of a savory bone, and by a contortion of the face, similar to that we have observed in a child who has unfortunately mistaken Aloes for Liquorice.

No sooner had the man of wrath and phials retreated from the field of blood, than Mr. Twaddleton advanced to the suffering artist, deeming the moment of bodily fear as affording a favourable opportunity for an attempt to reclaim him from the error of his ways. "Tom Plank," said he, in a mild tone, "hadst thou given ear to the warning voice of thy spiritual pastor, and, instead of ridiculing his advice at the sixpenny club, hadst, like a true Christian and worthy parishioner, given heed unto it, thou wouldst not, at this time, have been placed in such bodily peril. Mr. Seymour has consoled thee by his opinion; sincerely shall I pray that his judgment may be confirmed by the result, and that the visitation may have a salutary influence upon thy future conduct. Quit the pursuit of these bubbles, and leave wiser men to investigate the secrets of nature; let me exhort thee to return to thy craft, sow where thou canst reap; we cannot have figs from thorns, nor grapes from thistles; remember the proverb, "an emmet may work its heart out, but can never make honey. One word more and I have done—suffer not the artist whose profit it is to furnish thee with materials, to flatter and cajole thee—'the dog wags his tail, not for thee, but for thy bread.'"

As the party left the house, they met Mrs. Seymour, with Tom and Louisa, whose looks sufficiently testified the anxiety they had suffered.

"Is it all over? Is he dead?" asked Mrs. Seymour.

"No, no; he is quite safe; it was an extremely slight accident, although Doseall wished us to believe that it was likely to terminate in some dreadful manner. The vicar thinks that it may prove the means of driving science *out* of Tom Plank's head, and I intend to make it subservient to driving it still farther *into* ours."

"What do you mean?" cried Tom.

"I mean that it was an extremely apposite accident for illustrating the subject, upon which we were engaged at the moment of interruption."

"This is the second accident then," observed Louisa, "that will have served us in our scientific studies. What a philosopher," continued she, "must Dr. Doseall become, if he profit by every accident he witnesses!"

"Knowledge, my dear girl, is not promoted by the opportunity of seeing, but by the faculty of skilfully observing, and reflecting upon what we see; were it otherwise, the merit of a traveller might be at once estimated by the number of shoes he had worn out. Whenever, therefore, you hear of a discovery having been made *by accident*, do not, on that account, depreciate the merits of its author. It is certainly true, that many an important truth has been brought to light from some casual observation (28), but the dexterity with which such observation was applied constitutes the merit of the discoverer. Well, but to show in what manner the accident of Tom Plank bears upon the subject under discussion:—He had ignorantly fired a quantity of oxygen and hydrogen gases in a tin vessel; the consequence of the combustion was the immediate formation of a *vacuum:* and what happened? Why, the pressure of the external air, not being any longer balanced by elastic matter in the interior of the apparatus, crushed it with violence, as any other enormous weight might have done; and so ended the accident, which report magnified into a most awful catastrophe."

As the party proceeded on their way home, they continued to discourse on the subject of the air's pressure.

"If the atmosphere exerts so enormous a pressure, and has so much weight," observed Louisa, "it is strange to me that it should not fall down on the earth."

"Mr. Seymour replied, "that the air was a peculiar fluid, which from its elastic properties, was distinguished by the term of an *elastic fluid*, the particles of which were too far distant from each other to exert any cohesive attraction amongst themselves."

"But I suppose," said Tom, "that it gravitates, or is attracted by the earth; what then can be the reason, as Louisa says, that it does not fall, like any other body, to the ground?"

"And so it actually does," replied Mr. Seymour. "The lower stratum of the atmosphere rests upon the ground, but the strata above it do not fall, because they are supported by the particles beneath them, in the same manner as the water at the surface of a basin is supported by that at the bottom: the only difference in these two cases arises from the one being an elastic, and the other an inelastic fluid; so that the air after compression resumes its original dimensions; and since the atmosphere, by the action of gravity, is always in a state of compression, so is it always endeavouring to expand itself."

"If, then, the force of gravity were diminished," observed Louisa, "the air would become much lighter, and I suppose that is the true reason of its being so much less dense in the upper regions."

"Scarcely," replied her father. Have you forgotten the explanation* which I lately gave you, of the diminution in the weight of bodies, at a distance from the earth's surface."

"I recollect it perfectly," exclaimed Tom; "and it explained to us the reason that a marble fell from the top of a house, and from the ball of St. Paul's, with the same velocity."

"And yet I am quite sure," said Louisa, "that I have lately read an account of the air being so extremely light, upon the top of a high mountain, as to affect the breath and occasion great uneasiness."

"I do not deny the fact, my dear, I only question your explanation of its cause. Can it not, think you, be accounted for upon some other principle than that of the diminished force of gravity?"

Louisa was unable to suggest any other probable reason.

"The fact, then," said her father, "is simply this; since the air is elastic, or capable of yielding to pressure, so, of course, the lower parts must be more dense, or in a greater state of compression than those which are above them. In a pile of fleeces of wool, are not the lower fleeces pressed together by the weight of the superior ones, and do they not lie light and loose, in proportion as they approach the uppermost fleece, which receives no external pressure, and is confined merely by the force of its own gravity?"

"Clearly" said Louisa.

"Well then, we will suppose, for example, that the whole column of the atmosphere were divided into a hundred parts, and that each of these parts weighed an ounce, would not the earth, and all things on its surface, be, in such a case, pressed upon with the whole hundred ounces?"

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* See page 33.

"No one can deny that," said Tom.

"The lowest stratum of air," continued Mr. Seymour, "would be pressed upon by the ninety-nine ounces above it; the next by ninety-eight; and so on, until we arrived at the ninety-ninth stratum from the bottom, which would, of course, be subjected to no more than one ounce of pressure, or to the weight of the last and highest stratum."

The children were perfectly satisfied with this simple explanation; and Tom enquired whether, for the same reason, the water at the bottom of the sea must not be very dense, and unlike that we are accustomed to observe on the surface; his father, however, corrected this notion by stating that water, not being, like air, elastic and compressible, would not suffer any material diminution in volume, although pressed even by the enormous weight of the superincumbent ocean.

"But this would not be the case, if we could dig a pit to the centre of the earth," said Tom; "the air, I suppose, in that case, would be very dense at the bottom."

"The density of the air," replied his father, "would, undoubtedly, materially increase as we descended; because the air is compressible. It has been calculated that, at the distance of thirty miles below the surface, the air would have the same density as water; and, at the depth of forty-two miles, that of quicksilver; while, at the centre, it would probably be more solid than any substance of which we have any idea, for its density would be thousands of millions of times greater than that of mercury."

"Before we quit the subject of the air's elasticity," said Mr. Seymour, "we will consider the philosophy of the *pop-gun*, an amusement with which, I have no doubt, you are well acquainted."

"Indeed I am, papa; but do you allude to the quill, or to the wooden pop-gun?"

"The principle in both is the same; tell me, therefore, the origin and nature of the force which enables you to shoot your pellet to so considerable a distance."

"It depends upon the action of the air," replied Tom.

"Undoubtedly: but your answer is too general; I wished you to state, in precise terms, the changes which the air undergoes upon this occasion. You first ram in your pellet to the further end of the tube, do you not?"

"To be sure; and then I drive in a second pellet, and on forcing this forward, the first flies out with prodigious force."

"Very well: now examine what takes place; on propelling forward your second pellet, you condense the air which is enclosed between the two, until its elastic force becomes so great as to overcome the friction of the first pellet; thus released, the air expands with considerable force, and imparts a rapid motion to the pellet."

"I have frequently heard of the air-gun," said Louisa, "I suppose it depends upon a similar principle."

"It does; and it affords a very striking example of the surprising force which air is capable of exerting, when condensed to a considerable degree; for, by means of this instrument, bullets may be propelled with a force very nearly equal to that of gunpowder."

"It is a curious fact," observed the vicar, "that although the air-pump is a modern invention, yet the air-gun, which is so nearly allied to it in the construction of its valves and condensing syringe, should have existed long antecedent to it; for it is recorded that an air-gun was made for Henry IV. by Marin, of Lisieux, in Normandy, as early as 1408: and another was preserved in the armoury at Schmetau, bearing the date of 1474."

"But the air-gun of the present day," said Mr. Seymour, "is very different from that which was formerly made, and which, like the pop-gun, discharged but one bullet, and that after a long and tedious process of condensation, while it is now made to discharge five or six without any visible variation of force, and will even act upon a dozen, but with less effect."

"I feel very curious to learn something more about this air-gun," said Tom.

"There is a reservoir for the condensed air," replied Mr. Seymour, "which is secured by a nicely constructed valve, and which is made to open by pulling the trigger of the gun, so that a portion only of the air is disengaged, which, rushing into the barrel, gives motion to the ball."

"But how is the condensed air introduced into the reservoir?" asked Tom.

"By means of a condensing syringe," replied his father; "but I will take an opportunity of exhibiting the instrument in operation."

The reader will be pleased to recollect that the major agreed to pay a passing visit to the vicarage, it now becomes our duty to record what happened upon that memorable occasion; and we, perhaps, cannot better represent the nature of the discussion that took place than by relating the account as it was given by the belligerent parties themselves in conversation with Mr. Seymour.

"Well, gentlemen," said Mr. Seymour, "is it peace or war? I trust you have amicably adjusted all your differences."

"Upon my word," answered the vicar, "I have just reason to complain of the major's unjustifiable scepticism upon points that are perfectly unquestionable."

"You continue then to smart under the major's stinging criticisms, '*majore sub hoste.*' There is a Latin pun for your consolation," said Mr. Seymour.

"The vicar alludes, I suppose," said the major, "to the doubt I expressed respecting the authenticity of his leather money?"

"That is one of the many subjects, upon which I must say you have betrayed a deficiency in historical knowledge. Seneca informs us, that there was anciently stamped money of leather; and the same thing was put in practice by Frederick II. at the siege of Milan; to say nothing of an old tradition amongst ourselves, that in the confused times of the barons' wars, the same expedient was practised in England."

"You strangely mistake me," replied the major; "I never questioned the truth of these historical statements; I know full well that numerous substances have, at different times, and in different countries, been adopted in exchange, as conventional representatives of property. I have already stated that cattle were employed as the earliest measure of value (29). We find, for instance, in Homer, that the golden armour of Glaucus was valued at a hundred, and that of Diomedes, at ten oxen. Among the Indians, *cowries*, or small shells, are used; and the Abyssinians employ salt, bricks, and beads, for this very purpose; the ancient Britons are said to have circulated iron rings as money. The Hollanders, we know, coined great quantities of pasteboard in the year 1754; and Numa Pompilius certainly made money both of wood and leather."

"And yet you doubt the authenticity of my leathern money, which I am fully persuaded was coined in 1360, by John, king of France, who, having agreed to pay our Edward the Third the sum of 3,000,000 golden crowns for his ransom, was so reduced as to be compelled to a coinage of leather for the discharge of his household expenses.

"I have only questioned the authenticity of that specimen which I saw in your cabinet," replied the major; "and so must any person who views it through a medium unclouded by prejudice. I will stake my whole library to a hornbook, that our friend Mr. Seymour will agree with me in pronouncing it a fragment of the heel of an old shoe: let him observe the perforation, and say, if he can, that it has not been produced by a nail or peg. But really, my dear Mr. Twaddleton, you have forced me, much against my inclination, into this controversy."

"Very good, sir; very good! the heel of an old shoe, forsooth! But I thank you, Major Snapwell," exclaimed the vicar with some warmth; "I thank you, sir. Your assertion, while it evinces your own want of historical information, establishes, beyond doubt, the authenticity of my treasure, and the triumph of my opinion.

"Assuredly," said Mr. Seymour, with a wicked smile; "I dare say there may be numerous holes in this leathern coin; for many have been the antiquaries who have, doubtless, *pinned* their faith upon it."

"Psha, psha!" cried the vicar; "for once, at least, Mr. Seymour, let me entreat you to be serious; the subject, sir, is important, and merits your respect. It is from that very hole that I am enabled to identify the coin: yes, major, from that very hole, which you affect to despise, I am enabled to derive its principal claim to antiquity.

Are we not expressly informed, that the leathern money of John of France had a little nail of silver driven into it?"

"Well, then," continued the major, "what say you to that tell-tale stitch, which I so unfortunately picked out with my penknife?"

"Admirable ingenuity! most refined sophistry! provoking perversion!" exclaimed the vicar. "It is really amusing to observe the address with which the prejudiced observer distorts every fact to his own advantage. Why, bless me, sir, that stitch is strong enough to drag fifty such opponents out of the slough of unbelief."

"Do explain yourself," said Mr. Seymour.

"Explain myself! the stitch speaks for itself, sir. Were not these leathern coins strung together in different numbers, to facilitate payments? For, you will admit, that it would have been extremely inconvenient to have coined single pieces of leather, of different denominations. But stop, sir, stop; look at this, look at it, major, with care and attention. That," said the vicar, as he drew a small coin out of his waistcoat pocket with an air of imperturbable gravity and self-satisfaction, "is a current halfpenny, in lead, of James II.; and if your eyes are not hoodwinked by prejudice, you may probably perceive a piece of copper in its centre, which, we are told, was thus introduced for the purpose of rendering the currency lawful."

The dinner was announced before the conclusion of the discussion; and, as the reader will probably agree with us in thinking that a question of such grave historical importance ought not to be decided without due care and deliberation, we shall afford the disputants a reasonable time for reflection, and put an end to the chapter.

# CHAPTER XII.

THE SOAP-BUBBLE.—THE SQUIRT.—THE BELLOWS; AN EXPLANATION OF THEIR SEVERAL PARTS.—BY WHOM THE INSTRUMENT WAS INVENTED.—THE SUCKING AND LIFTING, OR COMMON PUMP.

"Tom," said his father, "bring me a saucer with some hot water; a piece of soap, and a tobacco-pipe. I have promised to teach John the art of blowing soap-bubbles."

Tom immediately proceeded to execute his commission, and shortly rejoined the party on the lawn, bringing with him all the necessary implements for bubble blowing. John, under the direction of his brother, made the lather; and Mr. Seymour, turning towards the elder children, asked them whether they understood the philosophy of the operation they had just witnessed; they were, however unable to return a satisfactory answer, and their father, therefore, proceeded as follows:—

"Most liquids, by agitation, exhibit the appearance of froth, in consequence of the escape of the air in small bubbles, which had been forced into them by the operation. If, however, the liquid be viscid and tenacious, like soap and water, the air is, as it were, imprisoned in the mass, producing the appearance which is commonly called *lather.*"

Louisa here inquired "Whether the air did not escape with more or less readiness, according to the degree of resistance it met with in the liquid."

"I thank you," said Mr. Seymour, "for having so kindly assisted me in the explanation."

Louisa smiled at this mark of her father's approbation, and Mr. Seymour proceeded,—"It is on that very account, that spirit, after it has been shaken, so soon regains its transparency; for, in consequence of the superior lightness of that fluid, and the little cohesion which subsists between its particles, the air makes a rapid escape. In like manner we may account for the spongy appearance which gives such superiority to our bread; in that case, the air disengaged during the fermentation of the dough cannot escape through so viscid a mass; it therefore remains, and thus produces the eyes or bubbles, which you may always observe in every well-baked loaf."

"See, papa," exclaimed Tom, "the bubbles, which John has blown in the lather, are not round, but angular figures—they appear to be like the hexagons which we used to cut out for our *papyroplastics*.

"They are certainly hexagonal," replied Mr. Seymour; "and the form arises from the pressure of the bubbles upon each other. The same appearance is to be seen in the pith of vegetables, when examined by the microscope, and is the result of the general re-action of the solid parts, similar to that which takes place in the honey-comb."

"I thought, papa," said Louisa, "that the form of the cells in the honey-comb was to be ascribed to the skill of the bee."

"That is a very general opinion, but it is not correct; it is now acknowledged by philosophers to be the effect of the mechanical laws which influence the pressure of cylinders composed of soft materials;—the nests of solitary bees are uniformly circular; and the cells of the pith of wood are only hexagonal in the central parts; towards the extremity, where there is but little pressure, they are circular.* I will take an opportunity of showing you the same fact in the berries of a lobster; but let us proceed to blow some bubbles. Plunge the bowl of the tobacco-pipe into the lather."

Tom obeyed his father's directions, and blowing through the stem, produced a bubble.

"See! see!" cried Louisa, "what a beautiful bubble! but there is a quantity of soap hanging to under part."

"I will take it off with my finger," said Mr. Seymour.

"There it goes!" exclaimed Tom.

"What beautiful colours it displays! as bright and gaudy as those of the rainbow," observed his sister.

"It has burst!" cried Louisa.

"Ah! my dear children," murmured the vicar, with an air of pensive gravity, "'*Tenues secessit in auras*,' as the poet has it. Even thus is it with all the full-blown bubbles of our fancy, raised by the breath of hope; the moment they appear most vivid and promising to our imagination, they vanish 'into air, into thin air,' like the gaudy and unsubstantial soap-bubble you have just witnessed; but proceed to blow another."

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* Davy's Lectures on Agricultural Chemistry, Lect. III.

"There is one!" exclaimed Louisa;—"see, it is of an oblong shape, like an egg!—there it goes,—but I declare it is now perfectly round!! —what can be the reason of its changing its figure?"

"I am glad you have asked that question, because my answer will serve to illustrate an important property of air, and which, indeed, is common to all fluids. While the upper part of the bubble was attached to the bowl of the pipe, its gravity being resisted, drew it into an elliptical form; but the instant it was detached, the contained air pressed equally in all directions, and the bubble, in consequence, became a perfect sphere.*"

"I do not exactly understand what you mean 'by pressing equally in all directions.'"

"The expression is surely sufficiently intelligible. Did you not learn in our conversation of yesterday, that air has weight, and exerts a pressure as much upwards as downwards and laterally? Were this not the case, how could the air in the interior of our bodies counteract the pressure of the atmosphere? The form of the bubble proves the same fact in a different way; for, had the air in its cavity pressed more in any one direction than in another, the bubble could not have been round, or, to speak more correctly, a sphere."

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* A scientific friend observed to the author that, as the globe possesses less surface than any other figure of equal capacity, it is of all forms that which is best calculated to allow the closest approximation of the particles of soap and water, and as there must exist amongst such particles a strong cohesive tendency, after having been forcibly stretched out, as it were, by the air blown into the bubble, it follows that, did no other cause operate, the bubble would assume the spherical form.

"What are you musing about?" cried the vicar, who had observed the attention of the boy riveted upon the bowl of the tobacco-pipe: "I am sure, from your countenance, that some circumstance is puzzling you."

"You are right, my dear sir; I was just then thinking how it can possibly happen, that the bubble should not have a hole in its upper part; for, while I am blowing it up, there must, of course, be a communication between my mouth and its interior, or else how could the air pass into it?"

"True," said his father; "but the act of throwing it off from the bowl of the pipe will unite this breach; for there exists a strong cohesive attraction between the attenuated particles of the lather; you will, therefore, perceive that, on this account, the bubble will be more readily and securely separated by a lateral than a perpendicular motion of the pipe."

"I wish," said Tom, "that I could discover some method of preventing their bursting so soon, for there is scarcely time to examine them before they vanish. What can be the cause of their short duration?"

"Consider, my dear boy, the frailty of their structure, and I think that the precarious tenure of their existence will cease to astonish you; indeed, the wonder is, that they should endure so long. The film, of which they consist, is inconceivably thin, so that the slightest impulse will be apt to rupture them; besides which, there must be a considerable evaporation going on from their surface, while the contraction of the contained air, from change of temperature, must also tend to limit their duration. You must likewise remember that the soap-lather will have a tendency to gravitate towards the depending part of the bubble, and, consequently, by quitting the upper portion, to render it of still greater tenuity. This last effect might, perhaps, be obviated, in some measure, by giving a rotatory motion to the bubble around its axis; but this, again, would accelerate the evaporation: which, after all, is the principal cause of the shortness of its duration; so that, unless this latter effect could be remedied, I despair of suggesting any expedient by which the frail existence of our airy structure could be protracted. You must, therefore, seek, from a succession of bubbles, the prolongation of an amusement, which no single one can afford you."

"And could not the evaporation be prevented?" asked Tom.

"If the bubble were blown in a glass vessel, and the latter immediately closed after the operation, it would remain for some time; I remember having once preserved a bubble in this manner for a very considerable period."

Tom, however, did not appear to relish this scheme; as, he said, the great sport arose from watching the movements of the floating bubble; the boy, accordingly, determined to pursue the amusement in the usual manner. His father, however, observed, that by mixing a solution of isinglass with the soap lather, larger, as well as more lasting bubbles might be blown; and Tom accordingly determined to make the experiment.

During this dialogue, little John had succeeded, for the first time, in launching the airy bauble. Imagination always tinges the objects of our first efforts with brilliant tints: no wonder, therefore, that John, with a shout of ecstasy, should have pronounced it to have been the most beautiful bubble he had ever seen; in truth, the sun was shining brightly, and the colours thus produced very justly excited the admiration of all present.

"I cannot understand the cause of these beautiful colours," said Louisa.

Mr. Seymour expressed a fear that, in their present state of knowledge, they would be scarcely able to understand the explanation he should afford them. "But," said he, "I believe you know that a ray of light is divisible into seven colours, and that when it passes through certain media, or is reflected from certain surfaces, this division is effected, and the various colours produced. (30) The film of the soap-bubble is one amongst the latter bodies; but I must refer you, for farther information upon this subject, to Mrs. Marcet's beautiful account of 'Refraction and Colours.'"

"I remember it well," said the vicar, "and have always considered it the most luminous chapter in the work."

"Now, Tom," said his father, "fetch your squirt, for we have not yet finished our enquiry into the effects of the air's pressure."

The squirt was produced; but it was out of repair: for, on attempting to fill it with water, the instrument entirely failed in the performance of its office.

"I see the defect," said Mr. Seymour, "which a little string will easily remedy."

A piece of string was instantly produced from that universal depot, the breeches pocket of a school-boy. Mr. Seymour said he should bind a portion of it around the end of the piston.

"What do you mean by the *piston?*" enquired Tom.

"The rod which moves up and down in the cylinder, or tube; and, unless its end fit so exactly as to prevent the admission of air, it is clear that the squirt cannot draw any water. It was for the pur-

purpose of making this part fit tightly that I wanted the string, and you will now perceive that the instrument is ready for use:—fetch me a vessel of water."

Tom soon produced the water, and on placing it on the ground, requested that he might be allowed to fill the squirt. This he accordingly effected without difficulty, and on pressing down the handle, he projected a stream of water to a considerable distance.

"I perceive," said Tom, "that the stream describes a curve like my ball."

"To be sure; it is under the joint influence of the same forces, viz. that of projection and of gravity. But explain the operation of the squirt?"

"As soon as I raised the piston, an empty space was left in the lower part of the cylinder, which I suppose would have remained as a *vacuum*, had not the water rushed into it."

"And why did the water rush into it?"

Tom hesitated.

"Was it not, think you, owing to the pressure of the atmosphere upon the surface of the water? When you raised the piston, the air above it was also raised, and ultimately driven out by the force of the ascending piston; and since the air could not find any entrance from below as long as the point was under the water, the interior of the squirt would necessarily have remained quite empty, or have been a vacuum, had it not been for the weight of the atmosphere, which, not having any counteracting pressure, drove the water into the tube, and thus filled it; and which, by pressing down the piston, you again expelled with considerable force."

"Your explanation," cried Louisa, "is so clear and intelligible, that I feel quite confident I could now explain any machine that owes its action to the exhaustion of the air, and the pressure of the atmosphere."

"If that be your belief," said Mr. Seymour, "I will not lose a moment in putting your knowledge to the test.—Tom, do you run into the house, and fetch hither the kitchen bellows."

The bellows were produced, and Louisa, having been desired by her father to explain the manner in which they received and expelled the air, proceeded as follows: "Upon raising the upper from the under board, the interior space of the bellows is necessarily increased, and immediately supplied with an additional quantity of air, which is driven into it by the pressure of the atmosphere; when, by pressing down the upper board, it is again expelled through the iron tube or nosle."

"To be sure," said Tom, "in the same manner that the water was expelled from my squirt, when I pushed down the handle."

"So far you are quite correct," said Mr. Seymour; "but you have not yet told us the use of the hole in the under-board, and which is covered, as you perceive, with a movable flap of leather: it is termed a valve, or '*wind-clap*.'"

"That," replied Tom, "is for the purpose of admitting the air, when we raise up the board."

"Exactly so; and also to prevent the air from passing out again, when you press it down. I wish to direct your attention particularly to this contrivance, because, simple as it may appear, its action will teach you the general nature of a valve. Without it, the operation of filling the bellows with air would have been so tedious as to have destroyed the utility of the instrument; for the air could, in that case, have only found admission through the nosle, and that, again, would have been attended with the additional disadvantage of drawing smoke and other matter into its cavity; when, however, you raise up the board, the air, by its external pressure, opens the wind-clap inwards, and thus finds an easy entrance for itself; and when you press the board downwards, the air, thus condensed, completely shuts the valve, and its return through that avenue being prevented, it rushes through the tube."

The children were much pleased with the simplicity of this invention, and Tom enquired of the vicar who first thought of it.

"We are informed by Strabo," replied Mr. Twaddleton, "that Anacharsis, the Scythian philosopher, who lived in the time of Solon, about six hundred years before Christ, invented the bellows, as well as the anchor, and potter's wheel; but," he added, "there is some reason to doubt the truth of this statement. The bellows, however, were certainly known to the Greeks; and the great poet Virgil alludes to them in his fourth Georgic:*

> ——'Alii taurinis follibus auras
> Accipiunt redduntque.'"

Mr. Seymour now proposed that they should proceed to consider the structure and operation of the pump.

"I suppose," said Louisa, "that the pump raises water in the same manner as the squirt."

"Exactly upon the same principle," replied her father; "but the machinery is a little more complicated, since its object is not to force the water out of the pump, at the same end of the pipe at which we draw it in. We will, however, proceed to the stable-yard, and examine the pump; and do you, Tom, provide a piece of chalk, in order that I may make a sketch of some of its principal parts."

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* Line 171.

The party immediately proceeded; and, as they walked along, Mr. Seymour desired the children to remember that the weight of the atmosphere was estimated as being equal to that of fifteen pounds upon every square inch of surface; and that the moment the water arrived at such a height as to balance that pressure, it could ascend no higher: he added, that the altitude at which such a balance took place was about 32 or 33 feet above the surface.

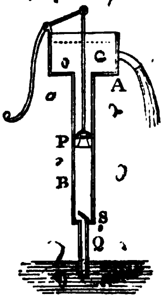
"If that be the case," said Louisa, "the pump, of course, can never raise water from any well of greater depth than that which you state."

"Not without some additional contrivance, which I shall afterwards explain to you," replied Mr. Seymour.

The party had, by this time, arrived at the pump; its door was opened, and as much of the apparatus exhibited as could be conveniently exposed. Mr. Seymour then chalked the annexed sketch upon the stable door.

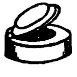
"Is that a pump?" asked Tom: "I should certainly never have guessed what you intended to represent."

"It is not a perspective drawing, my dear, but a representation of the different parts as they would appear, were it possible to cut the pump in halves, from top to bottom, without disturbing any of its arrangements. A drawing of this kind, which is frequently used for the sake of explanation, is termed a *section*."



Mr. Seymour here took an apple from his pocket, and having cut it in two, observed that the surfaces thus exposed presented *sections* of the fruit. This illustration was understood by all present, and Mr. Seymour continued, "I have here, then, a section of the common household pump. A B is the cylinder or barrel; P the air-tight piston which moves, or works within it, by means of the rod; Q is the 'suction,' or 'feeding pipe,' descending into a well, or any other reservoir; S the valve, or little door, at the bottom of the barrel, covering the top of the feeding pipe; and there is a similar valve in the piston, both of which, opening upwards, admit the water to rise through them, but prevent its returning. As this part of the apparatus is no less ingenious than it is important, I will sketch the valve, or *clack*, as it is termed by the engineer, on a larger scale."

Their father then chalked the annexed figure; from which its construction was rendered perfectly intelligible to the children.



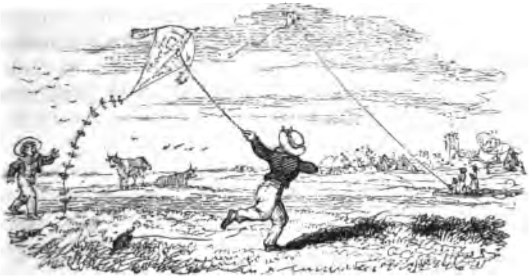
Mr. Seymour proceeded: "When the pump is in a state of inaction, the two valves are closed by their own weight; but, on drawing up the piston P, from the bottom to the top of the barrel, the column of air, which rested upon it, is raised, and a vacuum is produced between the piston and the lower valve, S; the air beneath this valve, which is immediately over the surface of the water, consequently expands, and forces its way through it; the water then ascends into the pump. A few strokes of the handle totally exclude the air from the body of the pump, and fill it with water: which, having passed through both valves, runs out at the spout."

"I understand how water may be thus raised to the elevation of 32 feet, but I have yet to learn the manner in which it can raise it above that distance," said Louisa.

"It is undoubtedly true that, if the distance, from the surface of the water to the valve in the piston, exceed 32 feet, water can never be forced into the barrel; but you will readily perceive that, when once the water has passed the piston valve, it is no longer the pressure of the air which causes it to ascend; after that period, it is raised by lifting it up, as you would raise it in a bucket, of which the piston formed the bottom; and water having been so raised, cannot fall back again, in consequence of the valve, which is kept closed by its pressure. All, therefore, that is necessary, is to keep the working barrel within the limits of atmospheric pressure; we have then only to fix a continued straight pipe to the top of the barrel, and to lengthen the piston rod in the same proportion, and the water will continue to rise at each successive stroke of the pump, until at length it will flow over the top of the pipe, or through a spout inserted in any part of its side. The common pump, therefore, is properly called the *sucking* and *lifting pump.*"

The party expressed themselves fully satisfied; and Tom enquired who invented the machine.

"It is an instrument of great antiquity," replied his father; "its invention is generally ascribed to Ctesebes of Alexandria, who lived about 120 years before Christ; but the principle of its action was not understood for ages after its invention. The ancients entertained a belief that 'Nature *abhorred* a vacuum;' and they imagined, that, when the piston ascended, the water immediately rushed forward to prevent the occurrence of this much-dreaded vacuum. In the seventeenth century a pump was constructed at Florence, by which it was attempted to raise water from a well to a very considerable altitude, but it was found that no exertion of this machine could be made to raise it above 32 feet from its level. This unexpected embarrassment greatly puzzled the engineer, until Galileo suggested that the pressure on the water below must cause its ascent into the pump, and that, according to this theory, when it had risen 32 feet, its pressure became equivalent to that of the atmosphere, and could, therefore, not rise any higher; and as they did not, at that time, understand the construction of the piston valve, the design was abandoned. It is now time to conclude your lesson. To-morrow I hope we shall be able to enter upon the subject of THE KITE.



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## CHAPTER XIII.

THE KITE.—ITS CONSTRUCTION.—THE TAIL.—AN AUTHOR'S MEDITATIONS AMONG THE CATACOMBS OF PATERNOSTER ROW.—WORKS IN THEIR WINDING SHEETS.—HOW MR. SEYMOUR STRUNG PUNS AS HE STRUNG THE KITE'S TAIL.—THE VICAR'S DISMAY.—THE WEATHER, WITH THE HOPES AND FEARS WHICH IT ALTERNATELY INSPIRED.—KITES CONSTRUCTED IN VARIOUS SHAPES.—THE FIGURE USUALLY ADOPTED TO BE PREFERRED.—THE FLIGHT OF THE KITE.—A PHILOSOPHICAL DISQUISITION UPON THE FORCES BY WHICH ITS ASCENT IS ACCOMPLISHED.—THE TAIL.—A SERIES OF KITES ON ONE STRING.—A KITE CARRIAGE.—THE MESSENGER.—THE CAUSES AND VELOCITY OF WIND EXPLAINED.

THE children were summoned into the library, and informed by their father, that he was at leisure to explain the philosophy of the kite; a subject with which Tom had repeatedly expressed some impatience to become acquainted.

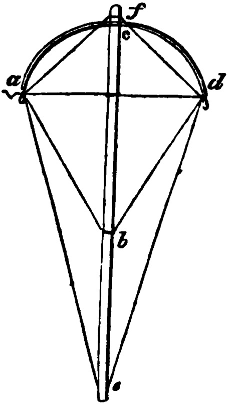
"It is a beautiful day," exclaimed the boy, joyously; "and there is such a delightful breeze, that I should really call it a complete *kite-day*."

"Gently, my fine fellow," replied Mr. Seymour: "the bird must be fledged, ere it can fly. We have not, as yet, any kite; for you know that the one you possess is shattered beyond the possibility of repair."

"True, papa; but could not Robert just step into the village and buy one? I saw several kites in the shop of Peg Robson yesterday."

"I do not doubt it, my boy; but the kites which are to be found in the toy-shop are made to sell, rather than to fly; and to *raise the wind*, for the benefit of the vender, rather than to be raised *by it*, for the amusement of the purchaser: we must, therefore, construct one for ourselves; and see, I have, accordingly, prepared all the necessary materials for the purpose. I have here, as you perceive, a straight lath of deal, about three quarters of an inch wide, and less than a quarter of an inch thick, and about four feet in length; this is quite ready for forming the standard, or *backbone* of the kite: and now for the bow. The cooper has complied with my directions, and sent an unbent hoop, as free as possible from knots; you observe that it is about the same length as the lath, but it will be necessary to pare it down a little at each end, in order to make it bend more readily to the required shape."

This having been accomplished, Mr. Seymour proceeded to form the framework of the kite in the following manner. He first ascertained the central point of the bow, by balancing it on his fore finger; he then affixed that point, by means of string, to the lath, at *c*, about an inch and a half from its upper extremity; a notch was next cut in each end of the hoop, or bow, *a d*; having fixed the string in the notch *a*, he drew it through another, *e*, previously cut in the bottom of the lath, and carried it to the opposite end of the bow *d;* the skeleton now presented the usual form of the kite. The next point, therefore, was to ascertain whether the two sides of the bow were in equilibrio, which he determined by balancing the lath on the finger, and observing whether it remained horizontal, or dipped on either side. This adjustment having been accomplished, Mr. Seymour next continued the string from *d* across the skeleton to the opposite notch *a*, giving it one turn round the lath in its way; from *a* it was carried to *f*, and wound round the top of the lath, and then again fastened at *d;* from *d* it was extended rather more than midway down the lath, and having been secured at *b*, was finally carried to, and secured in the notch *a*. The framework was now pronounced by Mr. Seymour to be complete.*



The next part of the process was to cover it with paper. Mr. Seymour observed, that the best kind which could be employed for this purpose was that known amongst stationers by the name of *fan paper*, so called from its being manufactured for the use of the fanmaker; its merits, he said, depended upon the size of its sheets, as well as upon the thinness and firmness of its texture; this, however, was not at hand, he was therefore obliged to rest satisfied with its best substitute, viz. folio sheets of large thin post.

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* The author has been thus minute, in order to afford his young friends clear directions for constructing a kite, and which, as far as he knows, are not to be found in any work hitherto published; and, he will also avail himself of this opportunity to state that the thin glazed linen of various colours, commonly known to haberdashers by the name of lining, has been found to be the best material as a covering for the kite. It is not only more durable than paper, defying the most boisterous wind, but superior to it as being secure from the effects of a shower of rain.

The party now went "ding-dong" to work; paper, paste, and scissors were immediately put in requisition. Sheets of paper were laid smooth on the table, and so arranged that each sheet overlapped its neighbour about half an inch. The skeleton of the kite was then placed upon them, and the paper was cut to its figure; a margin, of about three quarters of an inch, having been left around it, except over the bow where the margin, was extended to an inch in width: this arrangement was for the purpose of allowing the paper to turn over the framework, when pasted to it. This part of the work having been completed, and a sufficient time allowed for the drying of the paste, Mr. Seymour proceeded to fix the string, usually termed the *belly-band:* for this purpose, two holes were drilled through the lath, at equal distances from its edges; the upper one about a fifth part of the length of the kite from the top, the lower hole rather more than the same distance above its extremity.

The last, and by far the most important point, was to make the loop in the *belly-band.* If the kite be accurately constructed, its proper place may be easily found by extending the band, right or left, on the surface of the kite, and then marking the string at a point which lies in a line drawn from one end of the bow to the other; the loop must be made a little above such a point. If the kite be now suspended by this loop, the two ends of the bow ought to preserve a balance, and the lower extremity should dip below the upper part of the kite.

As Louisa observed the extreme care with which her father adjusted this part of the machine, she inquired into its use.

"I was myself about to put the same question," said her mother; "for its adjustment would appear to require as much accuracy, as that of the sash of a girl of sixteen."

Mr. Seymour informed them, they would hereafter find that the steady ascent of the kite into the air entirely depended upon such accuracy. "Have you not seen, Tom," asked he, "a kite rise sideways, or *plunge*, as it is called?"

Tom said he had often experienced that difficulty at school, but that he had attributed it to some defect in the tail.

"An error in the construction of the tail may, certainly, be occasionally the cause of such an accident, but it is more generally referrible to an improper position of the loop: if the kite *plunges*, you may conclude that this loop is placed too high; and should it whirl round in the air, you may infer that it is too low."

During this conversation Mr. Twaddleton entered the apartment; Tom was anxious to show him his newly-constructed kite, and while the party were asking him numerous questions, Mr. Seymour observed, that the vicar would be more profitably employed in making *bobs* for the string of the tail, than in finding answers for their string of questions.

Mrs. Seymour and her daughters, with Tom and the vicar, were, accordingly, placed round the table, for the purpose of carrying this project into effect, by a suitable division of labour. It was arranged that Mrs. Seymour should cut the paper, the vicar fold it, and Mr. Seymour tie it on the string.

"How long ought the tail to be?" asked Tom.

"And of what shape should the papers be cut?" enquired Louisa.

"And at what distances are they to be placed from each other on the string?" said Mrs. Seymour.

"I will answer all your queries," replied the father, "by giving you a dissertation upon this part of our machine."

"We shall now have an harangue," exclaimed the vicar, "as long as the tail itself; but pray proceed."

"The tail should never be less than twelve, and should it even amount to twenty times the length of the kite, its appearance in the air will be more graceful; this, however, must be regulated by the weight of the string, and by the length and thickness of the pieces of paper of which the tail is composed. The length of each ought to be about three inches and a quarter, and an inch and a half in breadth, and it should be folded four times longitudinally; each of these *bobs*, as they are called, must be placed at regular intervals of three inches."

"And with respect to the size of the wings?" asked the vicar.

"I should not recommend any wings; if the kite be well made, there cannot be any advantage from such appendages. Having now answered your several questions, let us proceed with our work.

"But where is the paper?" asked Mrs. Seymour.

"Apropos," answered her husband; "the box in which the London toys were packed contains a quantity that will answer our purpose."

The box was accordingly placed on the table.

"Why, what a most extraordinary miscellany!" cried the vicar; "the army of Mithridates could not have consisted of a more incongruous mixture. I perceive," added he, as his enquiring eyes glanced from sheet to sheet, "we have here a fragment of almost every description of literary and scientific work."

"The market," observed Mr. Seymour, "is supplied with waste paper from the catacombs of Paternoster Row, which may be truly said to 'level all distinctions.' Without intending any offence by a pun, my good vicar, what a *tale* will this box unfold! I never open a magazine of this waste paper, without feeling a deep sympathy for the melancholy fate of authors: to see the strange transmigrations, and vile purposes, to which their works are destined, is really heart-rending. That the *lights* of science should be consigned to the tallow-chandler! the works of the moralist, so well calculated to *purify* the world, to the soap-seller! that such a book as 'Laennec on the *Chest*,' with Dr. Forbes's valuable *Cases* in the bargain, should be *packed* off to the *trunk*-maker! are events which cannot fail to furnish food for melancholy reflection. Nay, more, I have myself (can you believe it, Mr. Twaddleton?) actually received a quantity of *ure*ic acid in a Review of Dr. Thomson's Chemistry! and I only yesterday learned, with horror, that a piece of fat bacon was positively wrapped up in a page of 'Paris on Diet;' while a Cheshire cheese came encased in Kitchener's 'Chart of the Moon.'"

"Oh, shameful! shameful!!" exclaimed the vicar: "but I can assure you, that this unfeeling conduct of the publisher had not escaped my notice and indignation; for I lately received a work against the slave-trade, in the fragment of a tract on 'the Progress of Cant;' and a copy of Irving's Orations, in an act of 'Much Ado about Nothing;' and what was still worse," continued the reverend divine, "a little work on the Art of Prognosticating the Weather, was forwarded to me in a chapter of *Daniel's* Prophecies."

"But let us quit these melancholy reflections for the present, and proceed with our occupation."

"If you compose the tail of your kite with these papers," said the vicar, "it will certainly vie with that of Scriblerus himself; you will have a knot of divinity, — a knot of physic, — a knot of logic, — a knot of philosophy, — a knot of poetry, — and a knot of history."

"Never mind, my dear sir; I wager an edition of Virgil, that I shall be able to discover in each page, with which you may present me, some apposite allusion to the *tail*, of which it is to form a part."

"Apposite allusion! impossible; as well might you attempt to connect the scattered leaves of the Sibyl: for example, here is an Epitome of the Roman History."

"Very well," said Mr. Seymour, "and pray is not that cur*tail*?"

The vicar dropped the paper in dismay; the treacherous design of his friend now, for the first time, flashed across his brain with a painful conviction, and he hastily retreated to a distant corner of the library, in order that he might find shelter from the pelting of a pitiless storm of puns, which he saw, too clearly, was about to burst on his devoted head.

On the vicar's retiring from the table, Mrs. Seymour approached the fatal box, observing, "that it was now her turn to explore the Sibylline cave."

"Here," said she, "is a list of the prices of some newly published works."

"That," replied her husband, as he cast a sly glance at the vicar, "is re*tail*; pray, proceed."

"We have next, I perceive, a prospectus for publishing all the speeches in the late parliament."

"That is de*tail*."

Here a deep groan from Mr. Twaddleton arrested the progress of the proceedings, and threw the whole party into a continued fit of laughter. As soon as tranquillity was restored, Mrs. Seymour again dipped her hand into the box, and drew forth the fragments of a work on Real Property.

"That," said Mr. Seymour, "is en*tail*; pray, *cut it off*, and give it to me."

"We have here," continued the lady, "the Memoirs of an Italian Bandit."

"Then prepare him for his fate; I have a noose quite ready for his reception."

"Here is a poem, entitled Waterloo."

"I will patronise it," said her husband; "and I warrant you that, under my auspices, the muse will soar to a greater height than she ever could otherwise have attained."

"We have here, I declare, a part of * * * pamphlet."

"Then I have lost my wager," exclaimed Mr. Seymour, "for I defy the power of man to make either head or *tail* of it."

Thus did Mr. and Mrs. Seymour proceed; the one cutting paper, the other cutting jokes; nor did the former cease stringing puns, until he had finished stringing the tail.

"I must now conclude by making a knot that shall not be in danger of becoming untied in the breeze," said Mr. Seymour: "but stop, stop one moment; I still require one more piece of paper to complete my task, and let it be double."

"Here then is a piece of paper, which, from its texture, appears to be well adapted to your purpose. Let me see, what is it? I declare, it is the titlepage of an Essay on Matrimony."

"Capital!" cried her husband; "a strange coincidence, truly; you have, indeed, furnished me with a knot that cannot be easily untied, however stiff may be the breeze; hand it over to me, for it will afford a very legitimate finish, and is generally the conclusion of every *tale:* but where is the vicar? What, ho! Mr. Twaddleton."

The reverend gentleman had so contrived to conceal his person in the corner of the room, behind a large folio which he had placed on a desk before him, that several moments elapsed before he was discovered; at length, however, a long-drawn sigh betrayed him in his retreat.

"Upon my word," exclaimed he, as he pushed aside the huge folio, your "volatility, Mr. Seymour, is wholly inconsistent with the gravity of a scientific instructor."

"But, at present," replied Mr. Seymour, "I am the manufacturer of a kite's tail; and, surely, upon such an occasion, *flightiness* ought not to be urged to my disparagement.

The party, shortly after this discussion, separated: Mr. Seymour retired to his own room; the vicar proceeded to the church to bury a patient of Doseall's; and the children ran into the garden to enjoy their rural sports.

On the following day, before the wings of the lark had brushed away the morning dew, had Tom and his sisters, buoyant with expectation, descended into the garden, in order to ascertain the state of the weather, and the direction of the wind but the sky was sullen and calm, not a breath disturbed the susceptible leaves of the aspen; all was repose—"a dread repose."

'No kite-day this," sighed Tom, with a countenance as lowering as the morning clouds.

"Have patience," said Louisa; "the wind may yet rise, it is only just six o'clock."

Thus did the minds of the children continue to hover between hope and despair, until after breakfast, when they determined to seek the gardener, and hold a grave consultation with that acknowledged judge of the elements; he told them that showers might be expected, but he thought it probable that the wind might rise after mid-day. "I will, however," said he, "consult my oracles; (21) after which, I shall be able to give you a satisfactory opinion." So saying, he left them; and, on his return, observed that "as the *Siberian sow-thistle* had closed itself the preceding evening, and the *African marigold* continued shut after seven o'clock in the morning, he had thought there would be rain; but," he added, "that upon inspecting the *poor-man's weatherglass*, the *Anagallis arvensis*, or *red pimpernell*, two hours ago, he had found it open, from which he concluded that the day would have been fine."

"There, Louisa; it will be a fine day, after all," exclaimed her delighted brother.

"No, indeed," continued the gardener; "on returning just now to the flower, which never deceives us, I found it had closed itself, so that rain is inevitable."

Nor was this opinion erroneous; for before the brother and sister could reach the lodge, the heavy clouds began to discharge their watery burthen, and the rain continued in one incessant shower for more than two hours; it then gradually abated, and the children, who had been anxiously watching it at the library window, were suddenly relieved from their anxiety by the appearance of the vicar, whom they espied slowly winding his way through the dripping shrubbery.

"'Heu! quianam tanti cinxerunt æthera nimbi?'

as Virgil has it," exclaimed the vicar, as he approached the portico, where Mr. Seymour and his family had assembled to salute him.

"We are under the influence of St. Swithin, vicar," said Mrs. Seymour, "and I fear there is but slender hope of its becoming fair."

"Psha! who cares for St. Swithin? (32) My barometer is rising rapidly, and I place more confidence in that classical deity, Mercury, than in a saint of so very questionable a character."

At this moment, Phœbus, as if delighted by the compliment thus bestowed upon his heathen brother, cast a sly glance from behind a dark cloud, and illumined the spot upon which the vicar was standing. In short, after the lapse of half an hour, the sun broke through the gloom, and a brisk gale followed; the countenances of the children sympathised with the face of the heavens, and the expression of hope lighted them up, in proportion as the sun illumined the departing clouds with its radiance.

"It is now quite fair, papa," cried Tom, in a voice of triumph, "and there is a most delightful wind; shall we not proceed at once to the common?"

"Presently," answered his father: "the ground is yet extremely wet."

In the course of an hour this objection had been removed, and the party prepared to set off on their kite-flying expedition.

"Bring me the kite, and let me sling it properly over Tom's shoulder," said Mr. Seymour.

"I will carry the string," exclaimed Louisa; "how nicely it is wound round the stick."

As the party walked forwards, the vicar asked Tom whether he knew from whence the name of the *kite* originated.

"A kite is a bird of prey," answered the boy, "which soars a great height; and, from remaining stationary in the air, was, I suppose, thought to resemble the paper kite."

"That is a very good explanation," said the vicar; "or it may, perhaps, have derived its name from the circumstance of its having been originally constructed in the shape of a bird of this description. In China the flying of kites is much more practised than in this country; and I understand that their shape is always that of some bird."

"In the London toy-shops you may constantly meet with them in such forms, as well as in many other fantastic shapes," observed Mr. Seymour; "and," continued he, "I remember to have seen, some years ago, a kite which resembled a man. It was made of linen cloth, cut, and painted for the purpose, and stretched on a light frame, so constructed as to resemble the outline of the human figure. It stood upright, and was dressed in a sort of jacket. Its arms were disposed like handles on each side of its body, and its head being covered with a cap, terminating in an angle, favoured the ascent of the machine, which was twelve feet in height; but to render it easier to be transported, it could be folded double, by means of hinges adapted to the frame. The person who directed this kind of kite was able to raise it, though the weather was calm, to the height of nearly five hundred feet; and, when once raised, he maintained it in the air by giving only a slight motion to the string. The figure, by these means, acquired a kind of liberation, like that of a man skaiting on the ice. The illusion, occasioned by this spectacle, did not fail, as you may readily suppose, to attract a great number of spectators."

"I believe, however," observed the vicar, "that the figure commonly adopted, is the one best calculated for the purpose."

"Undoubtedly," replied Mr. Seymour, "and for obvious reasons; the curvature of the bow enables it to escape the resistance of the air, as it rises; which, after having struck it, slides off, just as the current is more effectually turned aside by the gently curved prow, than by that which has a sharp outline; for the same reason, the mast of a ship, though it has a conical shape, is more easily drawn through the water with its broad, than with its narrow end, foremost; for although the primary obstruction is, no doubt, greater in the former case, yet the water heaped, as it were, on the front, is made to stream off with a slight divergency, and therefore does not hang on the sides of the mast, as it would in the latter case. This shape of the kite, moreover, presents the largest surface at the point upon which the wind can act with the greatest effect, while the whole is lightened by the removal of parts that would obstruct its action. The tail has also a greater control over a figure of such a description."

Mr. Seymour asked the vicar, "whether he could explain the origin of the French term for the kite, viz. *cerf volant*, or flying stag; I never can believe," continued he, "that the kite could ever have been constructed in the shape of that animal."

"I am unable to clear up the difficulty," replied the vicar; "and yet I have taken some pains upon the subject. The earliest notice of the kite, which I have been able to discover, is in a short English and French Dictionary, by Miege, which was published in the year 1690, and it is there described under the name of *cerf volant.*"

"I wonder," cried Tom, "who invented the kite?"

"In that, again," answered Mr. Twaddleton, "I am unable to furnish you with any satisfactory information. The pastime appears to be of very ancient date in China, and was, probably, first imported into Europe from that country."

"At what period, do you suppose?"

"Strutt, who was very assiduous and correct in all his antiquarian researches, was of opinion that its introduction into England could not be dated farther back than a hundred and fifty years."

The party had, by this time, reached Overton heath; the weather was favourable; and the kite impatiently fluttered in the breeze, while Tom was eagerly engaged in unwinding its streaming tail, and preparing the paper machine for ascent.

"Is the string fixed to the belly-band?" asked Mr. Seymour.

"All is ready," replied the vicar; "and I will hold it up, while Tom runs with it against the wind."

"There is not the least occasion to raise the kite from the ground," observed Mr. Seymour; "let its point rest on the grass, and place its tail in a straight line in front of it; I warrant you it will rise, as soon as Tom begins to run."

Tom immediately set off, and the kite rose majestically into the air.

"Give it string—give it string—gently, gently—now stop; there is no occasion for your running any farther, but let out the cord, as long as the kite carries it off vigorously, and keeps it fully stretched; but wind it up the moment its tension is relaxed."

"It is rising very fast," cried the breathless boy, "but the string burns my hand as it passes through it; I shall not be able to endure the heat."

"Be patient, and let it pass more slowly; put on your glove," said his father.

"Ay, ay; put on your glove," repeated the vicar; "even Xenophon himself, who declaimed so warmly against the effeminacy of the Persians, for wearing gloves, would scarcely have refused his consent to their use on such an occasion."

"What is it that produces so much heat?" enquired Louisa.

"The friction of the string," replied her father. "Do you not know that carriages frequently catch fire from the friction of their wheels, unless it be prevented by the application of grease?"

"Yes," said Tom; "and I have heard that the natives of some countries kindle their fires by rubbing pieces of wood together."

"The original inhabitants of the new world," observed his father, "throughout the whole extent from Patagonia to Greenland, procured fire by rubbing pieces of hard and dry wood against each other, until they emitted sparks, or burst into flame; some of the people to the north of California produced the same effect by inserting a kind of pivot in the hole of a very thick plank, and causing it to revolve with extreme rapidity: the same principle will explain how immense forests can have been consumed; for it is evident, that the violent friction of the branches against each other, from the agitation of the wind, would be fully adequate to the production of such an effect."

"You have also an excellent example of the effect of friction in producing heat," said the vicar, "in the history of the whale fishery; for, in harpooning the fish, unless the sailors observe the greatest caution in letting out the rope, its friction upon the side of their boat will be sure to set it on fire."

"And how do they manage it?" asked Louisa.

"As soon as the whale dives, (33) after having been wounded, it draws out the line or cord of the harpoon, which is coiled up in the boat, with very considerable velocity. In order, therefore, to prevent any accident from the violence of this motion, one man is stationed with an axe to cut it asunder, if it should become entangled; while another, with a mop, is constantly cooling with water the channel through which it passes."

"The kite is now at a considerable height," observed Tom; "but look at the string, how bent it is! I have repeatedly endeavoured to pull it straight, but without success."

"How could you have expected to succeed in the attempt? Consider the weight of such a long line of string."

"Then it is not the pressure of the atmosphere which gives it that curved form?"

"Assuredly not: have you so soon forgotten that the air presses equally in all directions, and would therefore tend to straighten, as much as to give a curved direction to the string? But, as you now appear to have let out the whole of your string, suppose you allow the kite to enjoy its airing, while we proceed to consider the philosophy of its ascent, and the nature and direction of those forces by which it is effected."

"The kite pulls so amazingly hard," cried Tom, "that unless I fix the string securely around the tree, we shall run the chance of losing it."

"I am well aware of the force it exerts," replied his father. "Dr. Franklin has said, that, with a good kite, a man unable to swim might be sustained in the water, so as to pass from Dover to Calais; but I agree with him in thinking, that a packet would be a much safer, as well as a pleasanter mode of conveyance."

"Now, then, for your explanation of the kite's ascent. Unless I am mistaken, you will find the subject much more complicated than you imagine," said the vicar.

"Not at all; Tom, who, I trust, has a perfect acquaintance with the composition and resolution of forces, will very readily understand the explanation I propose to offer. I admit, however, that there are some few points in the enquiry, which cannot be successfully treated without a knowledge of the higher branches of the mathematics; but I shall, of course, avoid all such difficulties.* Can you tell me, Tom, what advantage is gained by your running with the kite?" asked Mr. Seymour.

"I suppose that you thus obtain more force from the wind."

"Certainly; action and reaction are equal. By running, therefore, with your kite against the wind, you strike the air, and thus produce a reaction, which is equal to the force of the blow given to it. When the wind is high, and its action is not intercepted by surrounding objects, there cannot exist any necessity for such an expedient."

"The principle is the same as that which enables the bird to rise into the air by flapping its wings," observed the vicar.

"Unquestionably," replied Mr. Seymour.

"Does the kite, then, rise in the air, from the same causes that enable a bird to fly?" asked Tom.

"We are, not, at present, considering the ascent of the kite, but the advantage which is obtained by running with it: this latter, as the vicar has properly observed, undoubtedly depends upon the same principle as that which enables the bird to rise, by the motion of its wings, and which constitutes the third law of motion †, viz. that *action and reaction are equal;* that is to say, whenever one body exerts a force upon another, the second body opposes the first, with equal force, in an opposite direction. If, then, the bird strikes the air below it with a force which is equal to its weight, then must there be a reaction of the air, upwards, exactly equal to it; and the bird, being acted upon by two equal forces, in opposite directions, will, necessarily, rest between them."

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* Those readers, who are inclined to enter more deeply into the subject, may consult, with advantage, a memoir on the kite, by Euler, published in the Transactions of the Academy of Berlin for the year 1756.

† See p. 60.

"That is clear enough; but the bird *rises*," answered Tom.

"Because the force of the stroke is *greater* than the weight of the bird, and it therefore rises with the *difference* of these two forces; were the stroke *less* than its weight, then would it sink with the difference. Suppose, for example, a bird weighs *twelve* ounces, and it strikes the air with a force equal to *sixteen*, is it not clear that it must rise with a force equal to *four*? and is it not evident that, if it strikes the air with a force equal only to *eight*, that it must sink with a force equal to *four*?"

"I understand it perfectly; flying appears to be a very simple process; it would, surely, be an easy matter to contrive some sort of flapper, by which we might all be able to rise into the air," said Tom.

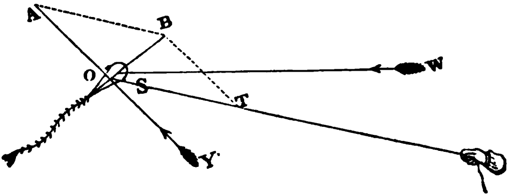
"Your opinion, my dear boy, is by no means singular; hundreds have entertained the same belief before you; and so confident was the famous Bishop Wilkins, that he declared it to be his conviction, that, in future ages, it will be as usual to hear a man call for his wings, as it is now to call for his boots."

"I do not see the difficulty," exclaimed Tom.

"The weight of our bodies is so great, that we have not sufficient muscular strength to impart a blow to the air that shall be equal to it. Now are you satisfied?" said his father.

"I am perfectly satisfied, if such be the case, that we can never hope to fly."

"The principle, however, which I have just explained," observed Mr. Seymour, "although it will fail us in our attempts to construct wings, is nevertheless extensively applicable in mechanics. A vane or fly, for instance, by resisting the air as it spins round, becomes the regulator of machinery. The intervals between the strokes on the bell of a clock are thus regulated, and the fly, on this occasion, is so contrived that this interval may be altered, or the clock made to strike faster or slower, by presenting the arms of it more or less obliquely to the direction in which they move. The same kind of fly is the regulator used in musical boxes, as I will presently show you, and indeed in almost all mechanical toys. Let us now return to the subject of the kite; for, as yet, we have merely considered the effect of increasing the wind upon its surface; we have next to enquire how the wind operates in raising it into the air.—Do you not remember, when I adjusted the noose in the belly-band, I stated that much depended upon this part of the apparatus? You will, at once, perceive that it will influence the angle which the kite forms with the earth, and I am about to prove to you, that the theory of the kite's ascent is materially connected with the value of this angle; but, in order to render my explanation intelligible, I have prepared a diagram, to which I am desirous of directing your attention.



"The kite here appears in the act of rising from the ground; the line W will represent the direction of the wind blowing upon it, all the currents of which we will suppose united in one; it is evident, from what has been already stated, that as it falls upon an oblique surface, it will be resolved into two forces, viz. into one parallel with it, and into another perpendicular to that surface; of which the force represented by the line Y will alone produce any effect, carrying the kite along the line O A, or in a direction parallel to itself; and you must have observed that this was the direction in which the kite was impelled, when you suffered it to rise, without checking its progress by the string."

"I remember that well," said Tom; "and I also observed that, when I pulled my string, the kite immediately rose more perpendicularly."

"To be sure it did; because, by that operation, you called a new force into action; which I have represented in the diagram by the line S T. The kite was therefore under the influence of the two forces O A and S T, and, since these are in the direction of the two sides of a parallelogram, it would not obey either, but ascend through O B, its diagonal."

"Notwithstanding Mr. Twaddleton's doubts upon the subject," said Tom, "I am sure that I perfectly understand your explanation; and I think I may also answer for my sister: but you have not yet told us any thing about the tail; I suppose, however, that it acts like the rudder of a ship, or the tail of a bird."

"Before I answer that question, let me inform you that the tail of a bird has not the least resemblance, in its action or uses, to the rudder of a ship."

"I always thought," said Tom, with some surprise, "that the bird was enabled to direct the course of its flight by the motion of its tail."

"That is a popular, but very erroneous opinion," replied his father: "the tail cannot perform the office of a rudder, since it never changes its situation with the direction of the bird, as the rudder does with that of the ship. Its principal use seems to be to keep its body poised, and upright."

"How, then, is the bird enabled to alter the course of its flight?" asked Louisa.

"It can easily turn, either to the right or left," answered Mr. Seymour, "by flapping the opposite wing with increased force, just as a boat is turned about to the right, by a brisk application of the left oar. In like manner the irregular flight of the butterfly, now up and now down, now to the right and now to the left, is no doubt effected by the wings striking the air one after the other, or perhaps with an alternate and unequal force. The object of such an action is obviously to baffle the pursuit of birds which always fly in a right line, whereas you see the butterfly does just the contrary."

"But you have not yet answered Tom's question," said the vicar. "Of what use is the tail of the kite? Does it assist its ascent, or is it merely an appendage of ornament?"

"In the first place, it keeps the head of the kite to the wind; and, in the next, it lowers its centre of gravity, and throws it towards its extremity, which not only prevents the chance of the machine being upset in the air, but so poises and regulates the position of the kite as to maintain the angle which it is necessary for the string to make with the surface."

Mr. Twaddleton here enquired what might be the most advantageous angle for the kite to form with the horizon, in order that the paper machine should rise to the greatest altitude.

"If the wind be horizontal," answered Mr. Seymour, "it is evident that the inclination of the kite's surface ought to be the same, as that which the rudder of a ship should make with the keel, in order that the vessel may be turned with the greatest facility; supposing the currents of water, which impel it, to have a direction parallel to the keel."

"And what ought that angle to be?" enquired the vicar.

"*Fifty-four* degrees, and *forty-four* minutes," replied Mr. Seymour.

Tom here interrupted the dialogue, by expressing a regret that he should have been provided with so small a quantity of cord.

"I do not believe, my dear boy, that any advantage could be gained by an additional quantity of string," said his father.

"Is there, then, any reason why the kite should not ascend, even above the clouds, provided that my string were sufficiently long and strong?"

"Yes; indeed is there a most unanswerable reason. Remember that the kite is made to rise by the operation of two forces; the one afforded by the wind, the other by the action of the string; now it is quite evident that, when the weight of the string, added to that of the kite itself, becomes equal to the force of the wind, acting upon the surface of the machine, a general balance, or equilibrium, of forces will be established, and the kite can no longer continue to ascend."

"Will it, then, remain stationary under these circumstances?" asked Louisa.

"It must do so, unless the force of the wind should abate; for it is a proposition in mechanics, which I shall hereafter endeavour to demonstrate, (34) that, if a body be acted upon by three forces, which are proportional to, and in the direction of, the three sides of a triangle, it will be kept at rest. The kite is exactly in this predicament, for its weight, the force of the wind, and the action of the string, fulfil these conditions, and consequently keep the kite stationary."

"Then I must give up my intention of trying to raise the kite above the clouds," said Tom.

"Although you may not be able to raise any single kite to the altitude you may desire, it is easy to accomplish your plan by a series of kites; the string of the first being attached to the back of the second, and so on."

"How, papa? I do not exactly understand you."

"Your kite," said Mr. Seymour, "is now as high in the air, as the force of the wind is capable of raising it; suppose you were to fix the end of the string you hold in your hand to the back of another kite, would not this second kite ascend as high as your first, by the same force, and your first kite therefore rise to double the altitude it is at present. In like manner you might attach a third kite, and so on."

"Now I comprehend it; and I should much like to try the experiment," said Tom.

"You shall certainly witness the effect I have described; but you must provide yourself with some stout string, for the force which the kites exert when thus arranged, is greater than you can easily imagine; indeed I question whether you would be able to hold them," observed his father.

Mr. Twaddleton here informed the young party that he had himself witnessed a carriage containing three persons that had been drawn along the road by kites, at the rates from fifteen to twenty miles an hour.

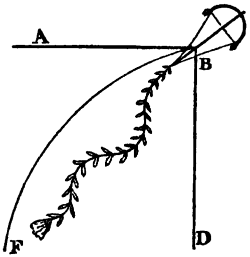
"I have seen the account of it," said Mr. Seymour, "and, if I remember right, the principal kite was preceded at the distance of about 120 feet by a smaller pilot one, which served to direct it away from any obstacles, such as trees, houses, &c. with which it might otherwise have come in contact."

"But how was the pilot kite made obedient to the will of the driver?" asked Louisa.

"By means of strings so attached to it that its surface was easily made to alter its angular position," answered Mr. Seymour.

"If my twine should snap," said Tom, whose attention was suddenly drawn to his kite from a slight unsteadiness in its motion, arising from a gust of wind, "we could easily recover it, that is one good thing; for it is hovering over the open field at the end of the heath."

"If you imagine that the kite, under such circumstances, would fall upon the spot directly under it, you are terribly deceived: recollect that, if the string should snap, the kite would be abandoned to two forces, those of the wind, and its own gravity; and you will perceive that, under such circumstances, it could not obey either of them, but would fall in an intermediate or diagonal direction. This fact will be rendered apparent by the annexed diagram. B A may be supposed to represent the force and direction of the wind acting upon the kite, and B D those of its gravity; then it is evident that, under the influence of these joint forces, it would describe the diagonal, and, for reasons already explained, that line must necessarily be the *curve* B F."



"Come," said the vicar, "before Tom draws down his kite, let us send up a *messenger*."

"What may that be?" asked Louisa.

"A piece of paper or pasteboard, which, on being introduced upon the string, is blown along the line up to the kite."

The *messenger* was accordingly prepared, and being placed upon the string, it ascended as Mr. Seymour had anticipated. While this operation was in progress, the vicar stood earnestly gazing upon the kite, and, at length, burst forth in the following animated soliloquy:—

"Assuredly, this must be acknowledged as a most beautiful and imposing toy! Fastidious or insensible must be that person, who does not feel exhilarated as he gazes on the kite, proudly floating under the canopy of heaven, and reflecting the departing smiles of the evening sun, after it has ceased to cheer us below."

"It has been said," observed Mr. Seymour, "to the disparagement of kite-flying, that as soon as the machine has been raised into the air, and all the string let out, the excitement of the sport is at an end, and that as nothing farther can be achieved, the interest of the performer from that moment begins to languish; now at this period the *messenger* will open a new source of pleasure and instruction, and may, by a little ingenuity, be made to afford a great diversity of amusement. I have therefore provided myself with several varieties of this machine. Here is one in the form of a dragon, which as it ascends, produces a very striking and almost magical effect. See, there it goes!"

The children were delighted, for the string upon which it was carried became at a certain height invisible; so that the figure appeared like a monster hovering in the air.

"I will now show you a *winged* variety of this apparatus, which we will name the *Brompton Mes-*

*senger* *. It consists of a hollow cylinder of stiff pasteboard, or thin wood, the diameter of which is sufficiently large to allow its free revolution round the string of the kite. To this cylinder are attached several flappers, or sails, in an oblique direction, like those of a windmill, each of which is covered with paper of a different colour. The action of the wind upon those oblique surfaces necessarily occasions a rapid rotation, upon a principle which I shall presently explain; and the beautiful effect thus produced, as the whirling body ascends, must be seen before it can be appreciated. I have some other contrivances of a similar nature, which it is my intention to prepare for your future amusement." (35)

"Has the kite ever been applied to any useful purposes?" asked Tom.

"Certainly," answered his father. "It was by means of the kite that Dr. Franklin was enabled to demonstrate the identity of electricity and the cause of lightning, and thus to disclose one of the most awful mysteries of nature."

"Pray do tell us something about this electrical kite, papa," said Louisa.

"Not at present, my love; it would divert us too much from the subjects in which we are engaged: at some future period I shall have much pleasure in introducing you into these fairy regions of philosophy."

"I just now remember reading in Miss Edgeworth's Harry and Lucy," said Louisa, "something about a kite and Pompey's pillar."

"I am glad that you have reminded me of that story," replied Mr. Seymour: "I will relate it to you. Some English sailors laid a wager, that they would drink a bowl of punch on the summit of

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* From associations of an interesting nature connected with the residence of the author's children.

Pompey's pillar. Now, that pillar is almost a hundred feet high, and it is quite smooth, so that there was no way of climbing to the top, even for sailors, who are such experienced climbers: so they flew their kite exactly over the pillar, and when it came down on the opposite side, the string lay across the top of the capital. By means of this string, they pulled a small rope over, and by this a larger one, that was able to bear the weight of a man; a pully was then fastened to the end of the large rope, and drawn close up to the upper edge of the capital; and then, you perceive, they could easily hoist each other up. They did more, for they hoisted the English flag on the top, and then drank the bowl of punch, and won their wager."

"That is a very good story," said the vicar; "but I cannot help regretting that so much ingenuity and labour should not have had a nobler end to accomplish."

"There is some truth in that observation," said Mr. Seymour, "and I will, therefore, relate another story which shall be more congenial to your heart, and in which the kite will present itself in a more interesting point of view; for, instead of enabling the sailors to drink a bowl of punch at an altitude otherwise inaccessible, we shall find it engaged in rescuing them from the horrors of shipwreck." *

"Pray, proceed, papa."

"No, my dear, upon reflection, I think it will be better that we should postpone the story, until your return to the lodge, when you shall read it in 'Harry and Lucy.' I will also point out to you in the same work, an account of a new and useful ap-

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* Transactions of the Society for the encouragement of Arts, vol. xli.; and Miss Edgeworth's Harry and Lucy, vol. iv. p. 288.

plication of the messenger, which will prove to you how successfully the faculties of youth may be encreased and improved by those very amusements which are too generally regarded as idle and unprofitable: I shall at the same time exhibit one or two experiments in illustration of the nature and causes of wind."

"Shall we not return immediately?"

"No, my dear; it would not be in my power to attend you at present; but join me in the library after dinner; Mr. Twaddleton will now accompany me to the village, and do you remain and enjoy the amusement of your kite."

It was not until the evening, that Tom and his sisters requested their father to fulfil the promises he had made them in the morning.

"You told us," said Louisa, "that you would give us some information about the wind; the subject has been puzzling me ever since, for I cannot make out the cause of it."

"Wind, my love, is nothing more than air in motion; and is produced by a large volume of it flowing in a current, or stream, from one place, or region, to another, and with different velocities."

"And what can produce these currents?" asked Tom.

"After the explanation of the action of the pump, I do not think that I shall have much difficulty in making you understand the nature of the operations by which wind is occasioned. Suppose a partial vacuum should be formed in any region, would not the neighbouring air immediately rush in to supply the deficiency and restore the balance?"

"Undoubtedly; from the pressure of the air behind it."

"Heat," continued Mr. Seymour, "will produce a partial vacuum, by rarefying the air, and thus rendering it lighter; in consequence of which, it will ascend, and the colder air will rush in to supply its place."

"I do not exactly see why the rarefied air should ascend," observed Louisa. "It appears to offer an exception to the general law of gravity."

"Not at all; on the contrary, its ascent is occasioned by the force of gravity; in the first place, however, to prove the fact that heated air does actually ascend, we have only to observe the direction of smoke, as it issues from the chimney; this consists of minute particles of fuel carried up, by a current of heated air, from the fire below; and as soon as this current is cooled by mixing with that of the atmosphere, the minute particles of coal fall, and produce the small black flakes which render the air, and every thing in contact with it, so dirty in a populous city."

"But I want to know, papa, what it is which causes the hot air to ascend?"

"The greater weight of the cold air above it, which gets, as it were, beneath the lighter air, and obliges it to rise; just in the same way as a piece of cork, at the bottom of an empty vessel, is made to rise to the surface of the water which may be poured into it."

"Now I understand it; pray, therefore, proceed with your account of the wind. You have just said that heat rarefies the air, and causes it to ascend."

"And thus produces a current of air, or a *wind*."

"Is heat, then, the cause of wind, papa?" asked Tom.

"It is one great cause; but there are, probably, several others; I will, however, exemplify this subject by an experiment."

So saying, Mr. Seymour produced a water-plate, a large dish, and a jug filled with cold water. The bell was rung, and the servant entered with a tea-kettle of boiling water.

The large dish was then filled with the cold, and the water-plate with the boiling fluid.

"Let this large dish represent the ocean," said Mr. Seymour, "and this water-plate, which I will now place in its centre, an island in that ocean; for the land, from receiving the rays of the sun, will be more heated than the water, and will consequently rarefy the air above it.—Now, Tom, light me the wax taper."

"I have done so."

"Then now blow it out."

"I cannot imagine what you are about, papa; —'Light the candle, and then blow it out!'—but it still smokes, shall I put the extinguisher over it?"

"By no means; give it to me, and observe what will happen when I carry it round the edge of the dish."

"The smoke goes to the centre," exclaimed Tom.

"Showing, thereby, the existence of a current towards the water-plate, or island; in consequence of the air above it having been heated, and therefore rarefied. This explains in a very satisfactory manner, a fact which may be constantly observed in our own climate, viz. a gentle breeze blowing from the sea to the land in the heat of the day. Upon the same principle it is, that most of the winds in different parts of the globe may be readily accounted for." (36)

"I suppose," said Tom, "that the air must rush with great velocity, in order to produce wind."

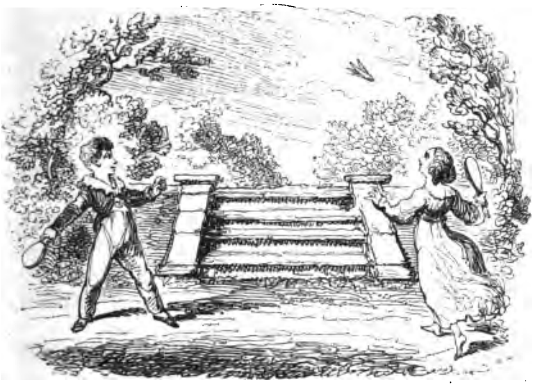
"A very general error prevails upon this subject," replied his father; "the rate of motion has been greatly exaggerated. In a brisk gale, even, the wind does not travel with such velocity, but that it may be easily traced by the eye; and the sailor is able to watch its progress by the ripple which it produces on the sea."

"Has, then, the rate of its motion ever been estimated?" asked Louisa.

"When its velocity is about two miles per hour, it is only just perceptible. In a high wind, the air travels thirty or forty miles in the same period. In a storm, its rate has been computed as being from sixty to eighty miles. It has, also, been ascertained, by experiment, that the air, as it rushes from a pair of blacksmith's bellows, has not a velocity above that of five and forty miles in the hour."

"At what rate, should you think the air travelled this morning, when we flew our kite?" enquired Louisa.

"I should think at about five miles an hour, for it was a pleasant but gentle breeze."



## CHAPTER XIII.*

A SHORT DISCOURSE.—THE SHUTTLECOCK.—THE SOLUTION OF TWO PROBLEMS CONNECTED WITH ITS FLIGHT.—THE WINDMILL.—THE SMOKE-JACK.—A TOY CONSTRUCTED ON THE SAME PRINCIPLE.—THE BOW AND ARROW.—ARCHERY.—THE ARRIVAL OF ISABELLA VILLERS.

Mr. Twaddleton, on his arrival at the lodge, on the following morning, was informed that Miss Villers was expected at Overton in the evening.

"Your account of that young lady," observed the vicar, "has greatly prepossessed me in her favour; I only hope that she is not too *blue*."

"I care not how blue the stockings of a lady may be," said Mr. Seymour, "'provided her petticoats be long enough to hide them;' and from my knowledge of Miss Villers, I can assure you, exalted as are her attainments, they are so veiled by feminine delicacy and reserve, that they may insidiously win, but will never extort our homage."

"Ay, ay," exclaimed the vicar; "I perfectly agree with you in your idea of feminine perfection —short tongues, and long petticoats, Mr. Seymour —But where are my little playmates?"

"I left Tom and Fanny on the terrace, a short time since," replied Mr. Seymour, "very busily engaged in the game of shuttlecock and battledoor."

"The shuttlecock is an ancient sport," observed Mr. Twaddleton. "It is represented in a manuscript as far back as the fourteenth century; and it became a fashionable game amongst grown persons in the reign of James the First."

"It is a very healthy pastime," said Mr. Seymour, "and, in my opinion, is admirably calculated for females; for, it expands the chest, while it creates a graceful pliancy of the limbs."

"I entirely agree with you; it is the only game with which I am acquainted, in which muscular exercise is gained without compromising gracefulness. But see, here come the two young rogues."

"Papa," exclaimed Tom, "I have been considering whether there is any philosophy in the game of shuttlecock."

"There are two circumstances connected with its flight," replied his father, "which certainly will admit of explanation upon scientific principles; and I should much like to hear whether you can apply them for that purpose. The first is its spinning motion in the air; the second, the regularity with which its base of cork always presents itself to the battledoor; so that, after you have struck it, it turns round, and arrives at your sister's battledoor in a position to be again struck by her, and sent back to you."

"I perfectly understand what you mean; but I really am not able to explain the motions to which you allude," said Tom.

"The revolution of the shuttlecock, about its axis, entirely depends upon the impulse of the wind on the oblique surfaces of its feathers; so that it is often necessary to trim the feathers of a new shuttlecock, before it will spin."

"I understand you, papa; the force of the wind, by striking the oblique feathers, is resolved into a perpendicular and parallel force, as you explained to us, when we considered the action of the wind upon the kite."

"Exactly; every oblique direction of a motion is the diagonal of a parallelogram, whose perpendicular and parallel directions are the two sides. Having settled this point, let us consider the second; viz. how it happens that the cork of the shuttlecock always presents itself to the battledoor."

"I should think," said Tom, "that the cork points to the battledoor for the same reason that the weathercock always points to the wind."

"Admirably illustrated!" exclaimed his father; "the cork will always go foremost; because the air must exert a greater force over the lighter feathers, and therefore retard their progress. While we are upon this subject, I will introduce to your notice some contrivances which are indebted to this same principle for their operation. In the first place there is the arrow; can you tell me, Louisa, the use of the feathers which are placed round its extremity?"

"To make its head proceed foremost in the air, by rendering its other end lighter, and therefore more sensible to the resistance of the air," replied Louisa.

"Very well answered; that is, unquestionably, one of the objects of the wings of an arrow; but there is also another, that of *rifling* it, or steadying its progressive motion, by causing it to revolve around its axis. If you will look at this arrow, you will perceive that the feathers are placed nearly, but not quite, in planes passing through it; if the feathers were exactly in this plane, the air could not strike against their surfaces when the arrow is in motion: but, since they are not perfectly straight, but always a little aslant, the air necessarily strikes them, as the arrow moves forward; by which force the feathers are turned round, and with them the arrow or reed; so that a motion is generated about its axis; and its velocity will increase with the obliquity of the feathers. You will therefore observe that, in order to enable the feathers to offer a necessary resistance to the air, they must possess a certain degree of stiffness or inflexibility. It was on this account that Roger Ascham*, and other skilful artists in the days of archery, preferred the feathers of a goose of two or three years old, especially such as drop of themselves, for pluming the arrow; and the importance, as well as the theory of this choice, is confirmed by a curious observation of Gervase Markham†, who says that 'the peacock feather was sometimes used at the short butt; yet, seldom or ever, *did it keep the shaft either right or level!*'" (37)

"That is intelligible enough," said Tom, "the feather of the peacock must have been so flexible as to have yielded to the slightest breath of air; and now, as we are upon the subject of the arrow, do explain to us the action of the bow."

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* Toxoph. ed. 1571. folio 166.

† Markham's Art of Archerie, 1634.

"I shall readily comply with your request, before we part; but I am desirous, at present, of following up the subject before us, and of taking into consideration some other instruments which owe their motions to the action of the air upon oblique surfaces."

"Suppose," said the vicar, "you explain to them the action of the wind upon the sails of the mill."

"I should like to hear something about the windmill," observed Tom; "and, perhaps, Mr. Twaddleton can tell us who invented the machine."

"The invention is not of very remote date," replied the vicar. "According to some authors, windmills were first used in France in the sixth century; while others maintain that they were brought to Europe in the time of the crusades, and that they had long been employed in the East, where the scarcity of water precluded the application of that powerful agent to machinery."

"I had intended," said Mr. Seymour, "to have entered very fully upon the subject of the windmill; for, although it is a very common machine, its construction is much more ingenious than is generally imagined; it must also be allowed to have a degree of perfection, to which few of the popular engines have yet arrived: but to do ample justice to my subject, I should require several models which are not yet in readiness; besides, Tom's holidays have nearly passed away; I must therefore postpone the examination of the mill to some future opportunity, and content myself, at present, with an explanation of its sails."

"And let me tell you," observed the vicar, "that if you succeed in this one object, you will accomplish a task which has occupied years of mechanical research. The angle which the surface of the sails ought to make with their axis, in order that the wind may have the greatest effect, or the degree of *weathering*, as the millwrights call it, is a matter of nice enquiry, and has much engaged the thoughts of the mathematicians."

"My remarks upon that subject will be very general," said Mr. Seymour; "I shall explain the principle, without entering into the minutiæ of its applications. The vertical windmill, which is the kind in most common use, consists, as you well know, of an axis, or shaft, placed in the direction of the wind, and usually inclining a little upwards from the horizontal line. At one end of this, four long arms, or yards, are fixed perpendicular to the axis, and across each other at right angles; these afford a surface, on which a cloth can be spread to receive the action of the wind. To conceive why these sails should revolve by the force of the wind, we must have recourse to the theory of compound motion. It is very evident that, if a mill exposed directly to the wind should have its four sails perpendicular to the common axis in which they are fitted, they would receive the wind perpendicularly, an impulse which could only tend to overturn them; there is a necessity, therefore, to have them oblique to the common axis, that they may receive the wind obliquely, when their effort to recede from it causes them to turn round with the axis; and the four sails being all made oblique in the same direction, thus unite their efforts for the common object.

"You have not yet told us what degree of obliquity the sail ought to make with the wind," said the vicar.

"The same as the kite ought to make, *fifty-four* degrees and *forty-four* minutes," replied Mr. Seymour.

"Do you not remember, papa, when we were last in London, you pointed out to us a curious mill on the banks of the river, which went without any sails?"

"You allude to the horizontal mill at Battersea."

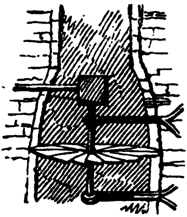
"I remember it was at Battersea," observed Louisa; "and I dare say, papa, that you recollect the strange story which the waterman, who rowed us down the river, told Tom and myself. He said 'that, when the Emperor of Russia was in London, he took a fancy to the neat little church at Battersea, and determined to carry it off to Russia; and that for this purpose he had sent a large packing-case; but, as the inhabitants refused to let the church be carried away, the case remained on the spot where it was deposited.'"

"It is not a bad story," said her father; "for the mill certainly, both in size and figure, may be imagined to resemble a gigantic packing-case. The mill, of which you are speaking, has been lately taken down, in consequence of its use having been superseded by the introduction of steam. It was erected by Captain Hooper, who also built a similar one at Margate. It consisted of a circular wheel, having large boards or vanes fixed parallel to its axis, and arranged at equal distances from each other. Upon these vanes the wind could act, so as to blow the wheel round; but had it acted upon the vane at both sides of the wheel, at once, it is evident that it could not have had any tendency to turn it round; hence, one side of the wheel was sheltered, while the other was submitted to the full action of the wind. For this purpose it was enclosed within a large cylindrical framework, furnished with doors or shutters, on all sides, to open at pleasure and admit the wind, or to shut and stop it. If all the shutters on one side were open, whilst all those on the opposite side were closed, the wind, acting with undiminished force on the vanes at one side, whilst the opposite vanes were under shelter, turned the mill round; but whenever the wind changed, the disposition of the blinds was altered, to admit the wind to strike upon the vanes of the wheel in the direction of a tangent to the circle in which they moved."

"Well; have you any other machine to explain to your scholars?" asked the vicar; "for," continued he, "I am anxious to present them with a bow and arrow which I have provided for their amusement."

"I will, if you please, first describe to them the mechanism of the smoke-jack; and I am desirous of doing so, as I have a very pleasing experiment to exhibit, which is founded upon the same principle."

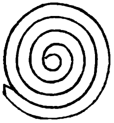
Mr. Seymour then described the more common form of this machine. It consisted, he said, of a number of vanes, of thin sheet-iron, arranged in a circle, as here represented, but all set obliquely at a proper angle of inclination. Its action was explained in the following manner:—When a fire is kindled in the chimney, the air which, by its rarefaction, immediately tends to ascend, strikes on the surfaces of the inclined vanes, and by a resolution of forces, similar to that already explained, causes the spindle, to which they are affixed, to turn round, and consequently communicates the same motion to the spit. The brisker the fire becomes, the quicker will the machine move, because in that case, the air ascends with greater rapidity.

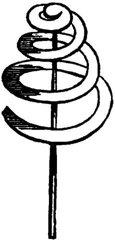


"I will now exhibit to you a mechanical amusement which is founded on the same principle," said

Mr. Seymour. "Fetch me the piece of pasteboard which lies on the library table."

The pasteboard was produced, and Mr. Seymour described upon it a spiral, similar to that which is represented in the annexed figure. The spiral was cut out, and extended, by raising the centre above the first revolution. It was then suspended upon a small spit of iron, which had been previously prepared; by applying the centre or summit of its spiral to its point. The whole was now placed on the top of a warm stove, (the application of a lamp would have answered the same purpose), and the machine, to the great delight and astonishment of the children, soon put itself in motion, and turned without the assistance of any apparent agent. The agent, however, in this case, was the air, which being rarefied by the contact of a warm body, ascended, and thus produced a current. The accompanying sketch may render this experiment more intelligible to the reader.





The vicar observed that, to him, the experiment was perfectly novel; although he remembered having seen what he now supposed must have been a similar contrivance; but which, until that moment, he had always considered as the effect of clockwork."

"And what might that have been?" asked Mr. Seymour.

"The revolution of a serpent, which I noticed in several windows in London, during a late illumination."

"Undoubtedly; it was nothing more than a spiral, so painted as to resemble that reptile, and which owed its motion to the action of air heated by a lamp placed beneath it."

"Now, then," exclaimed the vicar, "let us direct our attention to the bow and arrow; see the present I have provided for you, Tom!"

So saying, the worthy clergyman produced a bow and a number of arrows, together with a target; which, at his desire, had been sent from London.

"I think," observed Mr. Seymour, "that you should accompany your gift with some account of archery, or the art and exercise of shooting with the bow and arrow."

"That will I readily do," replied Mr. Twaddleton; who accordingly proceeded as follows:—

"The bow is the most ancient and universal of all weapons, and has been found to obtain amongst the most barbarous and remote nations. In the days of David the practice of the bow would appear to have been so general, that it was not unfrequently made use of as a figure of speech. Israel, when blessing his sons, says of Joseph, 'the *archers* have sorely grieved him, and shot at him, and hated him; but his *bow* abode in strength, and the arms of his hands were made strong, by the hands of the mighty God of Jacob.'"

"Its earliest application was probably for the purpose of obtaining food," observed Mr. Seymour.

"Your conjecture has the weight of testimony," replied the vicar; "when Isaac sent Esau to the forest, he said, 'Take, I pray thee, thy weapons, thy quiver, and thy bow, and go out to the field, and take me some venison:'* and it is even a question, whether the *Saxon* bow was ever used by the Anglo-Saxons and Danes for any other purpose than that of procuring food, or pastime; for the representation of this bow, in an ancient manuscript† of the tenth century, shows it to have been very differently constructed from what one might expect in a military weapon; in size, too, it was a mere toy, compared with the bow of succeeding ages."

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* Gen, xlix. 23, 24. † MS. Cott. Claud. B. IV.

"There can be no doubt that the bow and arrow were employed for the purpose of killing animals for food from the earliest times; but its principal interest is derived from its military applications; will you, therefore, give us a sketch of its history, and confine yourself to its practice as a warlike instrument in England?"

"And may I also beg of you, my dear sir," added Mrs. Seymour, "to explain the different terms which are employed to denote its parts and applications; such information will be, just now, highly acceptable to me, as I am reading some romances, in which those terms are constantly occurring."

"You shall be obeyed, madam," replied the vicar, with a courteous smile.

"We are, probably, indebted to the Norman conquest for the introduction of the bow and arrow as a hostile weapon; but, before I enter upon that subject, it is necessary to state, that the bows in use in England, have been of two kinds, the common or *long* bow, and the *cross* bow. The former does not require any description from me, the latter, or *Arbalet*, as it was called (from *Arbalesta*, i. e. *arcu-balista*, a bow with a sling), consists of a steel bow, fastened upon a stock, and is discharged by means of a catch, or *trigger*, which probably gave rise to the lock upon the modern musket."

"Excuse the interruption," said Mrs. Seymour, "but do allow me to ask whether *Arquebusade* does not derive its name from its having been formerly applied to wounds inflicted by the cross-bow or *Arbalet*?"

"I thank you, madam; that etymology is entirely new to me, and will explain the medical name, *Aqua vulneraria*, which has been applied to that spirit.

The vicar now proceeded without farther interruption.

"The invention of cross-bows is said by ancient writers to have come from the Sicilians. They were first used in England by the Normans at the battle of Hastings; and a *quarrel* or *bar-bolt* (which is synonymous with the arrow of the long-bow) was the immediate cause of Harold's death. In the reign of Stephen, in 1139, the second council of Lateran prohibited their use; and some historians assert, that they were not again used in this country till the reign of Richard I., whose death, occasioned by one at Chaluz, was considered as a judgment on his impiety. From the death of Richard till the splendid victories of Edward III., we hear little of the cross-bow as a military weapon. Its use appears to have been principally confined to the sieges of fortified places, and to sea-fights. In 1346, at the battle of Cressy, a large body of Genoese soldiers, who were particularly expert in its management, were in the service of the French; but at the commencement of the action, a sudden shower wetted the strings, and prevented the archers from doing their usual execution, while the English were still capable of annoying their enemies by the long-bow with complete success: both this victory and that of Poictiers, ten years afterwards, were chiefly ascribed by the English to their archers. In 1403, at the battle of Shrewsbury, where Hotspur was slain, the archers on both sides did terrible execution; and the victory of Agincourt, in 1417, was entirely owing to their skill. Under Edward IV. an ordinance was made, that every Englishman and Irishman, dwelling in England, should have a bow of his own height, to be made of yew, wych, hazel, ash, or any other seasonable tree, according to their power. By Henry VII. and his son Henry VIII. the use of the cross-bow was entirely forbidden; and a penalty of ten pounds was to be inflicted on every man in whose house one might be found. From this time they seem to have been chiefly used for killing deer.* Henry VIII. compelled every father to provide a long-bow and two arrows for his son at seven years old. Edward VI. Elizabeth, and James, all encouraged archery: John Lyon, who founded Harrow school in 1590, two years before his death, drew up rules for its direction, whereby the amusements of the scholars were confined to 'driving a top, tossing a hand-ball, running, and shooting.' The last mentioned diversion is in a manner insisted on by the founder, who requires all parents to furnish their children with bow-strings, shafts, and tresters, to exercise shooting. A silver arrow used some years ago to be shot for by the young gentlemen of that school."

The vicar concluded, and received the thanks of the party for the interesting information he had afforded them.

"There is one circumstance connected with the military history of the long-bow," said Mrs. Seymour, "which has somewhat surprised me; and that is, why it should so long have continued in estimation after the use of gunpowder."

"That circumstance," replied her husband, "will cease to astonish you, when you remember that, until the last century, muskets were very unwieldy instruments; they were never used without a rest; had no bayonets, and could not be so frequently discharged as they are at present."

"Come," said the vicar, "I perceive that the children are impatient to try their skill with their new instrument; let us walk out, and I will play the Scythian† upon this occasion."

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* See Shakspeare's Henry VI.

† The ancient nobility of Greece were instructed by the Scythians in the use of the bow, which in those days passed for a

"Now, Tom," cried Mr. Twaddleton; "we must have an object. Let me see. Shall it be the '*but,*' '*pricke,*' or '*roaver?*'* Come, try whether you can hit yonder gate-post. Take your bow, and here is an arrow."

Tom took the bow, and placing the arrow on the string, was about to draw the latter, when the vicar exclaimed, "Stop—stop—you must pull back your hand to your right ear, in order to shoot the arrow; whereas you have placed the bow directly before you, and are about to return your hand to the right breast."

"I thought," said Tom, "that was the proper position; for I remember reading of the Amazonian women, who are said to have parted with their right breasts, lest they should prove an impediment to their using the bow."

"I do not mean to assert," replied the vicar, "that there is not ample classical authority for your proceeding. The Amazons undoubtedly shot their arrows in such a position; and so, in truth, did the primitive Grecians; although the ancient Persians drew the arrow to the ear, according to the fashion of later ages, and which I greatly prefer for its superior convenience. You may also recollect, as you have been lately reading 'The Tales of a Grandfather,' that the superiority of the English archers was ascribed to this mode of using their bows; the words of Sir W. Scott, if I rightly recollect, are these, 'The archers of England were taught to draw the bow-string to their right ear, while other European nations only drew it to the breast.' Now," continued the vicar, "if you try

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most princely education. *Potter, Arch. Græc.* tom. ii. l. iii. cap. 4. *Aquin. Lex. Milit.* ii. 260.

* The '*but*' was a level mark; the '*pricke,*' a mark of compass, but certain in its distance; the '*roaver*' was a mark of uncertain length.

the difference of these postures, you will find that a much longer arrow can be drawn to the ear than to the breast, because the right arm has more room."

The party now amused themselves for some time; each shooting in his turn at the mark which was chosen for the trial; and with a success which, considering it was their first attempt, the vicar declared to be "quite marvellous."

At the conclusion of the sport, Mr. Twaddleton informed his friends, that parochial duties required his attendance at the vestry, but Mr. Seymour told him that he should expect his company in the evening.

It was just six o'clock, when the sound of the porter's bell, and the rolling of carriage-wheels, announced the approach of some important stranger to the lodge. It was Miss Villers. Were this a romance rather than an instructive history, we should, at once, charge our pencil with the glowing hues of the rainbow, and proceed to colour the outline which the imagination of the reader must have already sketched: but the character of the present composition fortunately renders such a task unnecessary; we say "fortunately," for the magazines of romance have actually become insolvent from the numerous and heavy drafts of the novel-writer; the regions of fancy have been so despoiled of their blossoms, that scarcely a flower can be culled by him who would entwine a garland for the brow of his heroine; and such even as may have escaped the grasp of this voracious horde, will be found to have faded under the withering influence of those insects of literature, which, fluttering or creeping about their petals, have rendered their fragrance pestilential, and turned their honey into bitterness. Where can be found the emblem of that damask lip which, arched like the bow of Cupid, shot an unerring dart, whenever a smile relaxed its tension? We might describe the perfect symmetry of her form, but what language could convey to the mind's eye the witcheries with which the graces had surrounded it? we might depict the features of her countenance, but how could we catch and fix the varying expressions which lighted it up with the magic glow of intelligence? We must, therefore, exercise the judgment of Timanthes, and leave the reader to the sway of his own imagination.

# CHAPTER XIV.

A CURIOUS DIALOGUE BETWEEN THE VICAR AND MISS VILLERS.—AN ENIGMA.—THE RIDDLES OF SAMSON AND CLEOBULUS.—SOUND.—HOW PROPAGATED BY AERIAL VIBRATION.—MUSIC.—A LEARNED DISCUSSION TOUCHING THE SUPERIOR POWERS OF ANCIENT MUSIC.—THE MAGIC OF MUSIC, A GAME WHICH THE AUTHOR BELIEVES IS HERE DESCRIBED FOR THE FIRST TIME.—ADVENTURES BY MOONLIGHT.—SPIRITS OF THE VALLEY.

On the following morning, Miss Villers, accompanied by her friends, proceeded to Osterley Park, to pay her compliments to Major Snapwell, and to add her entreaties to those of Mr. and Mrs. Seymour to induce the venerable Major to spend a few days at Overton Lodge. The children, of course, had a holiday; but was it a holiday? Tom and his sister have been frequently heard to declare that they never passed a more dull and listless day; and on resuming their scientific sports, their manner sufficiently testified that increased pleasure which always accompanies our return to an agreeable occupation.

"Mr. Twaddleton," said Miss Villers, addressing the worthy vicar as he entered the library at Overton, "I am happy to say that Major Snapwell has consented to pass a few days with us, and I learn from him that you have been most delightfully engaged in promoting a new scheme of scientific instruction; it is a subject which greatly interests me, and I shall be most happy in being allowed to become one of your party. To the merits of this system I am no stranger," continued the lady, "nor am I unacquainted, sir, with the advantages which your antiquarian knowledge has conferred; you have garnished the intellectual banquet with some of the choicest flowers of literature."

"You do me far too much honour, madam," said the vicar, as a gracious smile flitted over his countenance, "but I rejoice to find that you attach a becoming importance to the researches of the antiquary. May I be allowed to hope that you will favour me with a visit at the vicarage, and inspect my poor collection of antiques?"

"I anticipate a great treat, I do assure you," said Miss Villers; "but you speak too humbly of a collection which the major informs me contains some of the rarest relics of ancient days."

"The major, madam, is no doubt a judge, an excellent judge, although he is occasionally——but no matter—no matter. I certainly, as he justly says, do possess some few remarkable specimens. I have, for instance, an undoubted specimen of the leathern money coined by John of France; some very tolerable samples of tapestry of the 'high and low warp,' a series of sigilla or seals; as well as an interesting collection of impressions in wax, taken from grants of William the Conqueror, and what is curious, the colour of these waxen impressions is, without any exception, green, with a view, as it has been said, to signify that the acts should for ever continue fresh and in force. Let me consider," continued the vicar, "what other curiosities can I display for your delight and approbation? Rock-basins; yes, the rock-basins from Carn-breh. Ay, madam, you will be quite astonished at a specimen which—" At this instant, Mr. and Mrs. Seymour, followed by the children, entered the apartment, and abruptly cut the thread of the vicar's harangue.

"What do I hear," exclaimed Mr. Seymour. "Rock-basins! for mercy's sake, my dear vicar, let us not again dive into those horrid basins of

Druidism; do but consider the martyrdom I have suffered on account of those pools of lustration."

"Well, well," replied the vicar pettishly, "I will consent to reserve the question for Miss Villers's opinion, who, I have no doubt, will readily assent to their authenticity."

Mr. Seymour, anxious to extricate himself and the party from the cobwebs of antiquity, informed Miss Villers that he proposed to give his children a scientific lesson, and expressed his wish that she should witness the operation of his plan.

"I shall be grateful to you for so pleasing a privilege," answered Miss Villers; "but," continued she, "I beg to know whether you have not been lately teaching my young friends the operation of those various toys, which act by the force of the air; the object I have in view in asking this question you shall presently hear."

"Papa has lately taught us the reason of the kite's ascent, and the action of the squirt, sucker, and pump," said Tom.

"So I understood; and before you proceed with your sportive philosophy, I hope your papa will allow you to try whether you can solve an enigma I have composed for you."

"A riddle!" exclaimed Louisa; "how delightful! Pray read it, papa, and let us try to discover its meaning."

Her father then opened the paper with which Miss Villers had presented him, and read as follows:—

"Mortal, wouldst thou know my name,
Scan the pow'rs I proudly claim.
O'er this globe's capacious round
With fairy sprightliness I bound;
To ev'ry clime, to ev'ry soil,
With equal hand I give my toil.
O'er sea and land my power extends,
To ev'ry herb my care descends.

Did I withhold my vital breath,
Nature's forms would sink in death.
When confin'd, or swiftly driven
By angry spirits in the heaven,
My wrath in thunders I make known,
And Discord claims me as her own.
'Tis love of freedom makes me wild,—
When uncontroll'd, my nature's mild;
And oft the nymph, in dewy grot,
Seeks solace from my plaintive note;
O'er lovers' graves I waft a sigh,
And breathe the sound of sympathy.
And know, ye sons of Albion's isle,
That when the Hero of the Nile,
Midst crowds with mournful pomp array'd,
In the cold lap of Earth was laid,
I sympathis'd with Britain's tear,
And waved the banner o'er his bier.
'Tis I who, from the trembling lyre,
Breathe tones of love and soft desire;
'Tis I, the spirit of the shell,
Who fill with notes the listening dell;
And, when the war-trump sounds alarms,
'Tis I who summon men to arms.
To man a slave, though free as air,
I grind his corn, his food prepare;
Should he to foreign climes proceed,
He yokes me like the neighing steed,
And, by my quick but easy motion,
He traverses the stormy ocean.
His children, too, my presence court,
To give them toys, and make them sport:
Without my aid, their kites would lie
As useless weights that ne'er could fly;
Their humming tops would soundless spin,
Unless I breath'd a spell within.
The modest maid, without my power,
Would wither like her kindred flower.
Unless my cup of sweets she sips,
Where are the rubies of her lips?
Unless my glowing rouge she seeks,
Where are the roses of her cheeks?
What art, again, can strew her tresses
With half the grace my skill possesses?
Ev'n goddesses are represented
In draperies which I invented.

Sometimes, 'tis true, I am so frail
As ruffian-like to raise your veil,
And thus to curious man reveal
The charms you modestly conceal.
Revenge the deed. Announce my Name,
For now you know the powers I claim."

"It is extremely pretty," exclaimed Louisa.

"It is beautiful," said Tom; "but I should like to find out the riddle it contains. What can that be which grinds our corn, and carries our ships across the sea? Canvass? Yes; canvass clothes the sails of the windmill, and forms those of the ship."

"And therefore visits every clime; while, as long as the sails remain fixed, they are quite tractable and steady," added Louisa.

"It will not do, Louisa; it cannot be canvass: for the sail is never boisterous when it is controlled; but when let loose, it shivers in the wind and is very unruly; whereas it is said in the riddle, 'When uncontroll'd my nature's mild,' which is quite the reverse. Let me see. Can it be string? My top could not hum without string."

"How can string prevent the modest maid from fading like a flower? What says the vicar?" asked Louisa.

"*Davus sum, non Œdipus*," exclaimed Mr. Twaddleton.

At this moment Miss Villers whispered in the ear of her little favourite, who shortly afterwards exclaimed, "I have it, Tom,—it is AIR."

The juvenile group now attentively perused the enigma, in order to discover whether its different parts would admit of such an interpretation. As soon as they arrived at the passage in which was described the waving of the banners over the bier of Nelson, Tom declared that his sister must be wrong; and was proceeding to offer his reasons, when Mr. Seymour interrupted him, by observing, it was that passage which first suggested to his mind the solution of the enigma; and satisfied him that Louisa was perfectly right.

"It so happened," continued he, "that I was present during the awful ceremony of Nelson's interment in St. Paul's; and never shall I forget the thrilling effect which was produced on the assembled multitude, by the solemn movement of the banners in the dome, as the bier slowly advanced along the aisle of the cathedral; and which was accidentally occasioned by a current of air from the western entrance, although, to the eye of fancy, it seemed as if some attendant spirit had directed the colours, under which the hero had bled and conquered, to offer this supernatural testimony of respect and sorrow."

Miss Villers observed, that Louisa had unquestionably solved the riddle.

"And pray, my dear Mr. Twaddleton," said Mrs. Seymour, "what say you to these puzzles and rhyming conundrums? Do you hold them in as much horror as you would so many puns?"

"By no means, my good madam. An enigma is a perfectly orthodox species of composition; and is, indeed, sanctioned by the highest authorities of antiquity."

"I believe," observed Mr. Seymour, "that the pastime of riddle-making was extremely popular amongst the Grecians. Plutarch, if I remember correctly, has told us that the girls of his time worked at netting or sewing, and that the most ingenious amongst them 'made riddles.'"

"The most ancient riddle on record," replied the vicar, "is to be found in the fourteenth chapter of the book of Judges."

"*And Samson said unto them, 'I will now put forth a riddle unto you; if ye can certainly declare it me within the seven days of the feast, and find it out,* *then I will give you thirty sheets and thirty changes of garments.' And they said unto him, 'Put forth thy riddle that we may hear it.' And he said unto them, 'Out of the eater came forth meat, and out of the strong came forth sweetness.'*"

"And did they find it out?" asked Tom.

"My dear boy," replied the vicar, "you must read the chapter to which I have alluded, and you will thence learn all about this enigma."

"We have also numerous riddles in profane writers of ancient date," observed Mr. Seymour.

"Did you ever read of that invented by Cleobulus, one of the seven wise men of Greece, who lived 570 years before Christ?" enquired the vicar.

"Pray be so kind as to relate it," said Tom.

Mr. Twaddleton, in compliance with this request, proceeded as follows:—

"There is a father with twice six sons; these sons have each thirty daughters, who are particoloured, having one cheek white, the other black. They never see each other's faces, nor live above twenty-four hours."

"A very strange and unsociable family!" observed Louisa.

"I should never guess it," said Tom, "if I were to dedicate a year to it."

"You have, nevertheless, my boy, just pronounced the name of the said father, and that, too, after a single moment's consideration," replied the vicar.

"The name of the father!—how?—where?"

"It is a YEAR!"

"A year!" exclaimed the astonished boy.

"A year!" echoed Louisa; "to be sure it is; I now see it all clearly. His 'twice six sons' are the twelve months; the 'thirty daughters' the days of each month; and, since one day must necessarily pass away before the next can arrive, they may be truly said never to see each other's faces."

"Admirably expounded!" cried the vicar.

"And each day," added Tom, "is certainly 'parti-coloured,' as it is made up of light and darkness."

"Good, again! The quick apprehension of these my little playmates," said Mr. Twaddleton, as he turned towards Miss Villers, "is highly interesting; their minds, from well-regulated discipline, have acquired the faculty, if I may be allowed the useof the metaphor, of *winnowing* a subject, so as completely to separate the grain from the chaff."

"It is my intention to proceed this morning with the consideration of those toys which have the property of producing sound," said Mr. Seymour.

"I suppose you mean the whistle, whiz-gig, and humming top," observed Tom.

"Your papa, no doubt, alludes to those instruments," said the vicar, "and I greatly approve of the arrangement; since our last lecture embraced the operations of the atmosphere, a subject with which the nature of sound is certainly intimately connected."

"We have lately considered the phenomenon of wind, as produced by the motions of the atmosphere, and I now propose to investigate another species of agitation of which the air is susceptible, a kind of vibratory or tremulous motion, which, striking on the drum of the ear, produces SOUND."

"Is it the air which produces sound!" said Louisa, with much surprise, "I thought it was always occasioned by the vibrations of solid bodies. Well do I remember, when Tom struck the finger-glass, that you immediately silenced the sound by placing your hand upon it, and which you told us stopped the vibration of the glass, and so destroyed the sound."

"You speak the truth, but not the whole truth," replied her father. "Sound is undoubtedly the result of certain motions, or vibrations, produced in sonorous bodies, but these vibrations are communicated to the air, and from thence to the ear, in a manner which I shall presently explain."

"Do you mean to say, papa, that, if air were entirely excluded, bodies would be incapable of producing sound when struck?"

"Not exactly. Air is the usual conductor of sound, and unless some other medium be substituted, the removal of it would prevent a sonorous body from communicating any sensation to the ear. Liquids, however, are capable of conveying the vibratory motion to the organ of hearing; for sound can be heard under water. Solid bodies will also convey it, and in a much more perfect and rapid manner; (38) thus the slightest scratch with a pin, upon one end of a long piece of timber, will be distinctly heard on applying the ear to its opposite extremity. The tramping of a horse is to be perceived at a greater distance by listening with the ear in contact with the ground, than by attending to the sound conveyed through the air; and hence amongst many eastern tribes it is a common practice to ascertain the approach of an enemy by applying the ear to the ground. Upon the same principle, if we place our ear against a long brick wall, and desire a person at a considerable distance to strike it *once* with a hammer, it will be heard *twice*, the first sound travelling along the wall, the second through the air."

"I thank you for that hint," said the vicar. "I now understand the principle of a new instrument which Dr. Doseall employs for examining the pulsations of the heart. He places the end of a wooden rod upon the breast, and, applying the other extremity to his ear, declares that the sounds, thus conveyed to it, enable him to form the most accurate opinion in cases of diseased chest."

"In the same manner," observed Mrs. Seymour, "that you may hear the boiling of the tea-kettle, by placing the end of the poker on the vessel, and applying your ear to the handle."

"I do not exactly understand what you mean by a *sonorous* body. Will not every body produce a sound when struck?" asked Fanny.

"Those bodies are called *sonorous*, which produce clear, distinct, regular, and durable sounds, such as a bell, a drum, musical strings, wind instruments, and so on."

"And upon what does this peculiar property depend?" enquired Tom.

"Before I answer that question, I must explain the supposed nature of those vibrations of the air, upon which sound depends; you will then readily perceive why one species of matter should be better calculated than another for exciting them. It is generally believed that sound is conveyed through air by a succession of pulsations similar to those which are occasioned on the surface of smooth water by throwing a pebble into it. This at first produces a small circular wave round the spot in which the stone falls; the wave spreads, and gradually communicates its motion to the adjacent waters, producing similar waves to a considerable extent. The same kind of waves are produced in the air by the motion of a sonorous body, which will of course be in the centre, and the waves or pulsations will diminish in strength as they recede from that centre, until at last they become too weak to produce any effect on the ear."

"When I strike a bell, then, do I produce exactly the same motion in the air, that I do in the water by throwing a stone into it?" asked Louisa.

"With this difference," replied her father, "that, as air is an elastic fluid, the motion does not consist of regularly extending waves, but of vibrations, which are composed of a motion forwards and backwards; the undulations of the air differ also from those of the water, in not being confined to a plane, but in diverging in all directions from the centre; or, in other words, the aerial undulations are spherical."

"It is a very puzzling subject," cried Tom.

"I cannot understand," said Louisa, "how the motion of the air can extend so as to convey sound to a distance, if, as papa says, the air moves backwards as well as forwards."

"I see your difficulty, and will endeavour to remove it; attend to me. The first set of undulations which are produced immediately around the sonorous body, by pressing against the contiguous air, condense it. The condensed air, though impelled forward by the pressure, re-acts on the first set of undulations, driving them back again. The second set which have been put in action, in their turn, communicate their motion, and are themselves driven back by re-action. Thus there is a succession of waves in the air, corresponding with the succession of waves in the water."

"Now I understand why sound requires some time to travel from a distant object to the ear, as you explained to us upon a former occasion,"* said Louisa.

"But you have not yet told us what renders a body sonorous," observed Tom.

"Its elasticity: a ball of damp clay, which does not possess this property, will produce no other sound, when struck, but that which arises from the condensation of the small portion of air between the clay and the hammer which strikes it. A hollow ball of brass will produce more sound, because it is elastic; but still very little effect will arise from this, since a ball is the worst shape for admitting of vibration, on account of its forming an arch or dome, in every direction, so that one part stiffens and sustains the other: but if such a ball be divided, and the edge of one half of it struck, a loud, clear, and distinct tone will be produced; because an hemisphere will admit of the exertion of elasticity, or of momentary change of figure, which is conducive to the perfection of sound; and accordingly the bells used for clocks, and for musical purposes, have generally such a figure."

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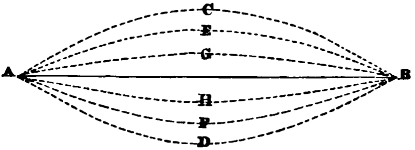
* See p. 36.

"I see clearly," said Louisa, "that it is the vibration of a sonorous body that communicates the necessary motions to the air; and I suppose that a body vibrates in proportion to its elasticity."

"Certainly it does; but to render this subject still more intelligible, I have prepared a diagram."

Mr. Seymour then exhibited a figure, of which the annexed is a copy, and proceeded to explain it in the following manner:—



"You are well aware that an elastic body, after having been struck, not only returns to its former situation, but having acquired momentum by its velocity, like the pendulum or swing,* springs out on the opposite side. If, then, I draw the string A B, which is made fast at both ends, to C, it will not only return to its original position, but proceed onwards to D. This is its first vibration, at the end of which it will retain sufficient velocity to bring it to E, and back again to F, which constitutes its second vibration; the third vibration will carry it only to G and H, and so on, till the resistance of the air destroys its motion."

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* See page 166. et seq.

"That is exactly like the swing or pendulum," said Tom.

"As you are struck with the resemblance, take care and preserve the remembrance of it; for I shall, hereafter, have occasion to revert to it."

"As I now understand how sound is produced and carried to a distance, I should much like to learn the cause of different tones," said Louisa.

"Fond as you are of music, my dear Louisa, I am not surprised at the wish you have just expressed to become acquainted with the nature of musical sounds; I shall, therefore, endeavour to convey, in as simple a manner as possible, the theory which has been proposed for their explanation. I think you will immediately perceive that, if the aerial waves which I have endeavoured to describe, should be irregular, or run into each other, there must arise a confusion of sounds; thus *discords* may be readily imagined to be produced whenever a second vibration shall commence before the first is finished, so as to meet it half way on its return, and interrupt it in its course. In like manner may we conceive the general nature of those arrangements upon which *unison* and *concord* depend: where the vibrations are performed in equal times, the same tone is produced by both, and they are said to be *in unison;* but *concord,* as you well know, is not confined to unison, for two different tones harmonize in a variety of cases. If, for example, the particles of one sonorous body vibrate in double the time of another, the second vibration of the latter will strike the ear at the same instant as the first vibration of the former, and this is the 'concord of an *octave*.' When the vibrations are as 2 to 3, the coincidence will be at every third vibration of the quickest, which, therefore, is the next degree of perfection, and is called a '*diapente*,' or 'fifth;' while the vibration of 3 to 4 will produce the '*diatessaron*, or 'fourth;' but this, and the next which follow in order, are not so agreeable to the judicious ear, and are therefore called '*imperfect concords*.'"

Louisa here enquired whether the difference in the acuteness of a sound did not depend upon the nature of the vibrations; and her father, in reply, stated that it depended entirely upon the degree of quickness with which the vibrations were performed: the slower the vibration, the graver the tone; the quicker, the more acute.

"But, if I strike any one note of the instrument repeatedly, whether quickly or slowly, it always gives the same tone," observed Louisa.

"To understand that fact," replied her father, "you must remember that the vibrations of bodies are regulated by laws very similar to those of the pendulum; consequently the duration of the vibrations of strings or chords depends upon their length, and thickness; for if two strings of equal magnitude, but with their lengths as 2 to 1, be equally stretched, their vibrations will be in the same ratio; therefore the shortest will make two vibrations, while the longest makes one: but the vibrations of the same string will always be the same whether it be struck quickly or slowly, upon the principal of the *isochronous* property of the pendulum, already described."

"Upon my word, Mr. Seymour," cried Mr. Twaddleton, "you are getting out of your depth; pray let us take leave of this subject, for I am quite sure that my young friends have already received more than they can carry away."

"I submit, my good sir; and in return for my compliance," said Mr. Seymour, "use your influence over Miss Villers, and induce her to favour us with a practical illustration of our subject upon the piano-forte."

"Most cheerfully; but my intercession is quite unnecessary, for I am sure that our fair friend is no disciple of Tigellius."*

"I am ever ready, sir, to comply with the wishes of those I respect. I consider the caprice which our sex too often displays upon these occasions, as not only a breach of good manners, but an evidence of unpardonable vanity."

"Pray, Miss Villers, may I be allowed to ask whether you have ever directed your enquiries into the nature of ancient music? it must have been very superior to that of modern ages," said Mr. Twaddleton.

"Upon a question of such doubt and difficulty, I feel that it would ill become a person of my very limited knowledge to offer an opinion; although I am willing to confess that the subject has often engaged my attention; and you could not afford me a greater gratification than by clearing up some of those doubts which have perplexed me. It is, I believe, admitted, that we are unable to ascertain the real nature of ancient music: but it is evident that it was an art with which mankind was extremely delighted; for not only the poets, but the historians and philosophers, of the best ages of Greece and Rome, are as diffuse in its praises, as of those arts concerning which sufficient remains have descended to evince the truth of their panegyrics."

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* Horat. Sat. lib. i. sat. 3.

"Nothing, as you very justly observe, is now left us, but conjecture," said the vicar; "and yet it is impossible to read the accounts of the extraordinary effects produced by the different 'modes' of ancient music, without entertaining a strong conviction of its great superiority over that of modern times. What have we, my dear Miss Villers, to compare with the soft '*Lydian*,' the grave '*Dorian*,' or the furious '*Phrygian*;' to say nothing of the subaltern modes of Aristides Quintilianus and others; such, for example, as the '*erotic*,' '*comic*,' and *encomiastic*?' What modern strains can produce the effects which are recorded to have followed the performance of Timotheus, the director of the music of Alexander the Great? One day, while the prince was at table, the musician performed an air in the Phrygian mode, which made such an impression on him that, being already heated with wine, he flew to his arms, and was going to attack his guests, had not Timotheus immediately changed the style of his performance to the sub-Phrygian, or Lydian. This mode calmed the impetuous fury of the monarch, and induced him to resume his place at table. Music," continued the vicar, "has, in modern times, so fallen from this degree of majesty and power, as to induce some persons to doubt the truth of these historical statements."

"I confess, Mr. Twaddleton," said Miss Villers, "that I have always been inclined to regard ancient music as the mere vehicle of poetry; and to attribute to the power of the latter that influence which you appear to refer exclusively to the former."

"I am willing to admit," replied the vicar, "that in the ancient theatre, music always accompanied her sister science, assisting, animating, and supporting her; in short, that she was, in all respects, her friend and fellow labourer. '*Qualem decet esse* *sororem,*' as the poet has it: but does not this rather prove that poetry, in itself, was insufficient to produce its effects without the aid of music? In farther proof of the power of ancient music, permit me to remind you that Plato has said, 'No change can be made in music without affecting the constitution of the state;' and Aristotle, who seems to have written his Politics only to oppose the sentiments of Plato, nevertheless agrees with him, concerning the power which music has over mortals; and has not the judicious Polybius told us that music was necessary to soften the manners of the Arcadians? In short, madam, music has lost its power over the passions of mankind, and this can only have happened in consequence of its having degenerated from its ancient purity and grandeur. If any one should have the hardihood to deny this my position, let him attend a modern rout in London. I have seen, my dear Miss Villers, a party at a whist-table, a dozen persons in *tête-à-têtes,* and as many solitary individuals, sitting like automatons, not one of them being moved by the concord of sweet sounds, with which some lady has been endeavouring to delight them. Had Timotheus appeared amongst them! hey, Miss Villers? I think I see the party at the whist-table, as his lyre successively changed from the Lydian to the Phrygian mode. I must, however, in justice state, that I once did see a lady lay down her cards in an apparent state of ecstasy, as a chorus of Handel suddenly burst upon her ear,"

"And what might that chorus have been?" said Mr. Seymour, "'*Blest be the hand?*' But, joking apart, you appear to have satisfied your mind upon a point which all the learning of Europe has left in a state of doubt and perplexity."

"I have merely delivered an opinion, sir; you perhaps will favour us with your judgment."

"The subject under discussion, my good sir, is one upon which no person can ever deliver a judgment."

"And pray, Mr. Seymour, why not?"

"For this plain reason, that it is not possible we can *hear* both sides."

"Psha! will you never cease to sully the pure stream of enquiry with the dregs of ridicule?"

"Well, then, to be serious; I agree with Miss Villers, that ancient music, whatever might have been its powers, was wholly indebted to the poetry which accompanied it for its influence over the feelings of mankind. It could not have been otherwise. The ancient instruments, as represented in sculpture, appear so simple as to be apparently incapable of producing great effects; and, indeed, amongst the writings of Aristoxenus, the oldest musical author, we cannot discover a trace of melody or harmony, such as we understand by *air* accompanied with different parts."

"To that very simplicity am I disposed to refer the charm of ancient music," said the vicar; "it was addressed to the *ear*, sir, whereas modern music is addressed to the *eye;* dexterity of execution is, now-a-days, more valued than beauty of composition; the sweetest shepherd that ever piped on his Doric reed, would be less applauded than he who can make his pipe squeak for the space of five minutes without respiration. The ancients knew better than to suffer the energy and accentuation of their rhythm to be so destroyed; and only mark, sir, the extreme jealousy with which they regarded every attempt to injure this simplicity; it even became a subject of legislation; and you no doubt remember the decree issued against Timotheus; which, as well as I recollect, ran thus, 'Whereas Timotheus the Milesian, coming to our city, has dishonoured our ancient music, and despising the lyre of seven strings, has by the introduction of a greater variety of notes, corrupted the ears of our youth; and, by the number of his strings and the novelty of his melody, has given to our music an effeminate and artificial dress, instead of the plain and orderly one in which it has hitherto appeared; rendering melody infamous, by composing in the chromatic, instead of the enharmonic. The kings and the ephori have, therefore, resolved to pass censure upon Timotheus for these things; and farther, to oblige him to cut all the superfluous strings of his *eleven*, leaving only the *seven* tones, and to banish him from our city, that men may be warned for the future, not to introduce into Sparta any unbecoming customs.'"

"And now, my dear vicar, have you done? Have you said all you think necessary, in defence of ancient music? If so, hear me, as the advocate of modern harmony. In the first place, there is not an anecdote which can be adduced in support of your side of the question, that may not be met with one parallel, and equally strong, in defence of mine. You cite the authority of Plato, to show that the constitution of a state may be affected by changing its national music. What said the great Lord Chatham?—'*Give me the making of the national ballads, and I care not who makes the laws;*' and the effects produced on the English people by Dibdin's songs, fully justified the maxim: but remember, Mr. Twaddleton, it was not the music, but the *poetry* of those songs, which kindled the patriotic feelings which saved our country; and I apprehend that this has been the case in all ages, where the power of music has been said to excite the feelings of the populace. We know that the ancient bards of our own country called forth the emotions of their hearers by the poetry of their songs; and with what success they practised their calling we may imagine from the fact that Edward the First, in his conquest of Wales, had recourse to the barbarous expedient of murdering all the bards, from the many obstacles they threw in his way, by the strong hold which they had over the minds of the people. You have told us a story of Timotheus, and the influence of his harp over a drunken monarch. If this is adduced in proof of the power of ancient music, you must, at least, admit that modern times have also had a Timotheus, who could excite or calm, at his pleasure, the most impetuous emotions. Henry III. king of France, says '*Le Journal de Sancy*,' having given a concert on occasion of the marriage of the Duke de Joyeuse, Claudin le Jeune, a celebrated musician of that period, executed certain airs, which had such an effect on a young nobleman, that he drew his sword, and challenged every one near him to combat; but Claudin, equally prudent as Timotheus, instantly changed to an air, *sub-Phrygian*, or *Lydian*, I suppose, which appeased the furious youth. But what shall we say of Stradella, the celebrated composer, whose music made the daggers drop from the hands of his assassins? Stradella was attacked by three desperadoes, who had been hired to assassinate him; but, fortunately, they had an ear sensible to harmony. While waiting for a favourable opportunity to execute their purpose, they entered the church of St. John de Lateran, during the performance of an oratorio, composed by the person whom they intended to destroy, and were so affected by the music, that they abandoned their design, and even waited on the musician to apprise him of his danger. Stradella, however, was not always so fortunate; other assassins, who apparently had no ear for music, stabbed him some time afterwards at Genoa."

"And thus afforded a practical illustration of a passage of Shakspeare," exclaimed the vicar,

" 'The man that hath no music in himself,
Nor is not mov'd with concord of sweet sounds,
Is fit for treasons, stratagems, and spoils;
The motions of his spirit are dull as night,
And his affections dark as Erebus:
Let no such man be trusted.' "

"Are you satisfied?" asked Mr. Seymour; "if not, I will proceed to tell you how Palma, a Neapolitan, induced a creditor who came to arrest him, not only to remit his debt, but to contribute a sum for his support. I will also relate an anecdote of Farinelli the actor, who having a pathetic air to sing on the stage to a tyrant who had taken him prisoner, the person who performed the part of the tyrant, and was to have refused his request, was so affected by the music, that he actually melted into tears, and clasped the captive in his arms."

"Enough, enough!" exclaimed the vicar. "I see plainly that you believe not in the power of music."

"In that you wrong me. I certainly do not believe that the ancients were better skilled than ourselves in music; and I have been anxious to convince you that there are as many modern as ancient stories, in proof of the influence of harmony over our feelings; but no one will deny that music is capable of producing extraordinary effects. Let us only interrogate ourselves, and examine what have been our sensations on hearing a majestic or warlike piece of music, or a tender and pathetic air sung or played with expression. Who does not feel that the latter tends as much to melt the soul and dispose it to pleasure, as the former to animate and exalt it? There is a celebrated air in Switzerland, which, I have no doubt, Miss Villers will presently play to us, called '*Ranz des Vaches*,' and which had such an extraordinary effect on the Swiss troops in the French service, that they always fell into a deep melancholy whenever they heard it. Louis XIV., therefore, forbade it ever to be played in France, under the pain of a severe penalty. We are also told of a Scotch air, '*Lochaber no more,*' which has a similar effect on the natives of Scotland. Never shall I forget the effect produced upon myself by the impressive requiem of Jomelli, as performed at the chapel of the Portuguese embassy to the memory of the late king of Portugal. The movement with which it commenced was a deep and hollow murmur, that seemed to swell from the tomb, and with which the voices of spirits imperceptibly rose, and intermingled;—a brilliant movement interposed,—it was a ray of hope, that pierced the gloom of the sepulchre!"

"I think," said Miss Villers, "that I can exactly appreciate the nature and extent of Mr. Seymour's opinion upon the question at issue. He does not deny the charm which the simple music of the ancients must have exercised over the hearer, although he attributes much of the effect to the poetry, of which it may certainly be said to have been the vehicle; and he evidently concurs with you, Mr. Twaddleton, in thinking that, owing to the intricate combinations of modern harmony, our astonishment at the execution of the artist too frequently overcomes the influence of the musical tones upon our passions. I perceive, however, from the expression of our friend's countenance," continued the young lady, "that, like a true antiquary, he clings to his subject, though his support be no stronger than a cobweb; under such circumstances I may be permitted to declare my sentiments upon the occasion, and I shall avail myself of this opportunity to express my humble testimony of gratitude, for the information and pleasure which I have just derived from your conversation. I believe then, gentlemen, that the language of modern music is no less forcible and expressive than that of ancient days; and if you will only allow me to exemplify this truth by an experiment, I feel convinced that the vicar will become my proselyte."

"Indeed, madam! Well, I will consent to trust the cause in your hands," said Mr. Twaddleton.

"Allow me then to ask you, sir, whether you have ever heard of a game, which is justly entitled to the appellation of the MAGIC OF MUSIC?"

"Never," replied the vicar; "nor can I imagine either the nature, or objects of such a game."

"Its object is to display the power of music as an expressive language; the manner in which I propose to exemplify it, I will, with your permission, explain in a very few words. The musical performer shall place herself at the harp, or piano-forte, surrounded by the party who are desirous of witnessing the pastime; the person to be operated upon must retire from the apartment, until the service which, under the direction of the music, it is determined he shall perform, is duly agreed upon and arranged. Such person is then to be re-admitted; not a word, look, or gesture, is to escape from any one present; by the expression of the music alone is he to receive his instructions, and, unless I am much deceived, you will find that this is amply sufficient for the purpose."

"My dear madam, the thing is utterly impossible," exclaimed the vicar. "It cannot be done; unless, indeed, you really possess the secret of the ancient '*modes*,' which were not even known to Meibomius, the learned commentator upon the Greek musician Alypius; nay, Isaac Vossius himself, the expounder of rhythm, were he now alive, would never credit it."

"Are you willing to make the experiment?"

said Miss Villers; "if so, be so kind as to leave the room for a few minutes."

The vicar accordingly prepared to depart, casting at the same time, upon his fair companion, a look which sufficiently expressed the scepticism he felt upon the occasion.

"But you have not told me," said he, "by what signal I am to return, and submit to the proposed ordeal."

"The music will inform you, if you pay sufficient attention to its language," replied Miss Villers.

The door having been carefully closed, the company were consulted, in a whisper, as to the service they should require the vicar to perform. "I should propose," said Miss Villers, "that Mr. Twaddleton be directed to take a rose out of the basket of flowers on the chimney-piece, and having smelt it, to carry it to the harp."

"And do you propose to express all these different movements by the aid of music? If you succeed, there must be an end to the vicar's scepticism," observed Mr. Seymour.

"If I fail upon this occasion, it will be the first time," said Miss Villers: "but you must all promise to be silent, and to maintain the most absolute command over your countenances."

Miss Villers seated herself at the piano-forte, and played off an elegant and sparkling overture, which so delighted Mrs. Seymour that she involuntarily exclaimed, "If music can be made to speak an intelligible language, it must be under the guidance of Miss Villers."

"Hush!" cried the performer, in a half whisper; "I am now about to summon the vicar into the room."

She accordingly, with exquisite taste and address, introduced the air of "*Open the door, Lord Gregory*," into which she infused so much expression that the vicar must have been as dull as Midas, had he not instantly caught its meaning. Nor were the lady's hopes disappointed. Mr. Twaddleton entered, and appeared as if anxious to address the performer; but an intelligible glance from Mr. Seymour recalled him to his duty, and hermetically sealed his lips. His intention had been, doubtless, to enquire whether his appearance were seasonable; but the question was anticipated by Miss Villers, who immediately on his entrance struck up the air of "*See the conquering Hero comes*," which, at once, satisfied his doubts, and conveyed, in language not to be misunderstood, the sanction of the enchantress, to whose spells he had so unreservedly entrusted himself.

The vicar had been told that he was to perform certain acts on his re-admission into the room; but, thought he, how am I to discover the thread which is to guide me through so perplexing a maze? I can discover at this moment nothing but a concord of sweet sounds, that would rather dispose me to listen in profound repose, than to enter upon any service of exertion. Miss Villers saw and guessed the nature of his embarrassment, and changing the melody, struck into the air of '*Hearken, and I will tell thee how*." She then, by a succession of well selected chords, which were now played "*piano*," and now "*forte*," convinced the vicar that she commanded an instrument fully capable of readily and forcibly expressing encouragement and repulse in all its degrees.

"Thus much then is certain," mentally ejaculated the vicar, "that she is enabled, by the aid of music, to signify her approbation, or disapprobation, of any act which I may attempt to perform. I accordingly predicate of this said music, that it is, *bonâ fide*, a logical weapon; inasmuch as it can affirm and deny. It, therefore, only remains for me, knowing as I do that I have some act to perform, to ascertain the '*locus*' or '*ubi*;' for the act in question, whatever it may be, must of necessity be done or accomplished '*in proprio loco*,' or in some definite part of the room." With this determination, founded, as he believed it to be, on the unerring basis of Aristotelian logic, he advanced towards the table; but the loud and discordant sounds of the instrument, at once convinced him that, however correct his notions might be with reference to the '*substance*' or first '*predicament*,' they were evidently erroneous as to the '*accidents*,' of 'time,' 'place,' and 'relation;' at least, such were the ideas that floated through the categorical organ of his cranium, and he accordingly faced about, and made a retreat towards the window; but the notes now became still more clamorous, and increased in vehemence. Ay, ay, thought he, it is quite evident that I am receding from the theatre of action; and with this conviction he diverted his steps into a different direction, and, in a slow pace, tracked the path by his ear, with as much sagacity as a dog follows his prey by his nose. As he approached the fire-place, the storm of sounds gradually subsided, until a peaceful murmur breathed around, which finally died away as the vicar placed his hand upon the chimney-piece. So then it appears, after all, that I have some service to perform at the fire-side. It is, doubtless, to sit down, thought he, as he espied the elbow-chair, which, at that moment, appeared to his fancy, as if stretching forth its hospitable arms to receive him; but scarcely had he answered the imaginary invitation of his old friend, by presenting the nether part of his person to its luxurious lap of down, than a sudden *sforzato*, or crash in the minor key, made him rebound upon his legs, as nimbly as though the cushion had been a bed of thorns. Miss Villers now resolved the discord, and dexterously dashed into an allegro movement, in which she introduced the air of "*How sweet are the flowers that grow!*"

The vicar's face mantled with a smile, as the bouquet on the chimney-piece met his eye, and harmonised with the sounds that floated in his ear. It is evident, thought he, that those flowers are the objects of my pursuit,—but what was he to do with them? The musician solved the question, by tastefully exchanging the former air for that of "*Ask if yon damask rose be sweet.*" No sooner had these notes delivered their melodious errand to the subtle ear of the vicar, than he instantly seized the rose, and carried it in triumph to his olfactory organs; at the same moment the music ceased. The pause, however, was but of short duration; for Miss Villers, by resuming her labours, intimated that some farther service was expected. Was he to return the rose? Certainly not; for the attempt was marked by strong disapprobation. Was he to take it out of the room? The music put a decided negative upon that movement; for the vicar had scarcely measured half the distance of the apartment before the air of "*Fly not yet*" arrested his steps. By a continuation of the same varying style of expression, and strongly marked rhythm, the vicar was shortly led to affix the rose upon the harp.

In closing our account of this interesting scene, it is scarcely necessary to describe the delight of the vicar, the astonishment of Mr. and Mrs. Seymour, the satisfaction of Miss Villers, or the boisterous mirth of the juvenile party. It was, in truth, a very extraordinary exhibition; and when the reader considers that, beyond what was furnished by the expressive language of music, the vicar did not receive a single hint for his guidance, he may, perhaps, cherish some scepticism upon the subject; but we can assure him that we have repeatedly witnessed, not only a similar, but a still more complicated performance of the same kind, and with equal success. (39.)

The evening of the day on which this musical divertisement was performed, was one of those which so frequently occur in August, when sultry heat is succeeded by refreshing coolness. Isabella Villers possessed a quick sensibility to the beauties of nature, and she quitted the drawing-room to enjoy, without interruption, that pensive quiet which maintained an undisputed dominion. The moon had but just risen, tipping the summits of the wood with silver, while it left the mass of foliage in deeper shadow. Never was there a fairy scene better calculated to awaken the emotions of the heart, or to kindle the energies of the imagination. The hour too was propitious to the indulgence of that undefined species of reverie which is the refinement of intellectual pleasure. Having traversed the winding path of the wood for some distance, she found herself in one of those sequestered glades we have formerly described. She seated herself on a rustic bench, tastefully formed out of an aged oak, whose venerable figure was bending under the hand of Time, and her mind was gratefully lulled into a pensive calm by the review of past events, as the ear is soothed by the murmur of wild and distant music. A sudden breath of wind, as it swept the foliage, startled her, and turned the current of her ideas from past scenes to future prospects, which her vivid fancy lighted up with cloudless sunshine. The moon, as if in sympathy, suddenly peered through the sylvan avenue, and threw her rays upon one of those statues which we have already described as giving such an air of classic sanctity to these secluded glades. It was the figure of TIME, which in the gloom of the wood had hitherto escaped her observation. To a mind of exuberant fancy, a leaf cannot fall to the ground, nor a zephyr waft the fragrance of the violet on its dewy pinions, without conveying some beautiful emblem of morality. Isabella rose from her seat, and approached the figure, whose hoary countenance appeared as if lighted up into a placid smile by the beams of the moon, which fell directly upon it; her eye glanced from his face to his scythe; its blade was hidden in a cluster of roses—Were I susceptible of a superstitious impression, thought Isabella, did ever a circumstance present itself better calculated to justify its indulgence? On the pedestal of the figure was a basso relievo, in which Time appeared in the act of shivering into pieces the club of Hercules with a crutch. In a few minutes she quitted the scene which, in spite of her better reason, she could not wholly divest of its prophetic influence, and proceeding along the winding path, at length descended into the valley. The moon was at this time shrouded in dark clouds, and although, by a painful effort, Isabella Villers summoned all the powers of her vision, the objects around her remained invisible, until the eye had so far accommodated itself to the gloom, as to recognise the white foam of the waterfall. The moon now gave a coy and furtive glance, the water for an instant sparkled in her beams, and then was lost in deeper shadow. A spectre of human form, but of gigantic stature, arose from the spot to which the eyes of Isabella had been directed —was it the spirit of the Fountain? It appeared to advance, but the moon once again shining forth in splendour, it vanished.

> "And what seem'd corporal melted
> As breath into the wind."

The courage of Isabella was destined to sustain another trial, for scarcely had the vision disappeared than she distinctly heard her own name pronounced; and since, from the direction of the sound, she well knew that the spot from which it issued was inaccessible, we ought not to feel surprised at her having at the instant referred it to a supernatural origin—it was, however, but the illusion of the moment, and she determined to return to the house, and submit the events of the evening to the judgment of Mr. Seymour. We shall not trespass any longer upon the patience of the reader, than to state that Miss Villers arrived safely at the lodge, and very shortly afterwards retired to rest. With your permission, gentle reader, we will follow her example; for, to say the truth, our lamp—that midnight sun which illumines the path of the author, is dimmed by the dark clouds that lower at its setting; our Pegasus, the pen, which has raced for so many hours over the snowy plains of foolscap, is fairly "done up," and refuses any longer to sip of that spring which can alone sustain its powers, and impart utility to its movements.

## CHAPTER XV.

ORIGIN OF THE CRESCENT AS THE TURKISH ENSIGN.—APPARITIONS DISPELLED BY PHILOSOPHY.—MUSICAL INSTRUMENTS CLASSED UNDER THREE DIVISIONS.—MIXED INSTRUMENTS.—THEORY OF WIND INSTRUMENTS.—THE JEW'S HARP.—THE STATUE OF MEMNON.—AN INTERESTING EXPERIMENT.—THE FLUTE.—THE WHIZ-GIG, ETC.—ECHOES.—THE WHISPERING GALLERY IN THE DOME OF ST. PAUL'S.—THE SPEAKING TRUMPET.—THE INVISIBLE GIRL.—OTHER ACOUSTIC AMUSEMENTS.

On entering the library on the following morning, Mr. Seymour informed Miss Villers, that Major Snapwell had taken his departure, in order to breakfast with the vicar, and that he had invited Tom and Louisa to accompany him, for the sake of inspecting the cabinet of medals; but he added, that he expected the return of the party at two o'clock, when he proposed to give them a lecture upon the philosophy of the several toys which are indebted for their action to atmospheric vibrations.

"Suppose, then," said Miss Villers, "that we walk towards Forest Lane, and meet them on their return. This arrangement," she added, "will afford me an opportunity of communicating to you the history of some adventures I encountered last evening, and of taking your opinion upon them."

"You well know," answered Mr. Seymour, "that you may always command my services—but you have really raised my curiosity: what can be the nature of the adventures you speak of?"

Miss Villers then entered into a particular account of all she saw and heard the preceding evening; with which the reader is already acquainted.

Mr. Seymour, however, suggested the propriety of abstaining from any discussion upon the subject until the children were present to hear it; for, said he, I am most desirous that they should be familiarized with those natural sources of illusion which enlighten the wise, while they minister to the superstitious fears of the ignorant."

They had not reached the entrance of Forest Lane, before they perceived the vicar with Tom and Louisa, followed by the Major.

"Papa,' cried Tom, as he ran to meet his father, "we have had a most delightful morning; amongst other things, do you know we have found out the meaning of the crescent which the Turks always wear, and use as their ensign."

"Indeed! well then, let me hear your explanation," said his father.

Major Snapwell and the vicar had by this time joined the party, and with their assistance Tom was enabled to offer the following account of it.—The crescent appears on the early coins of Byzantium, and was intended to commemorate the defeat of Philip of Macedon, who, as he was about to storm it on a cloudy night, was discovered by the sudden light of the moon. When the Turks entered Constantinople, they found this ancient badge in various parts of the city, and suspecting that it might possess some magical power, they assumed the symbol and its power to themselves; so that the crescent became, and still continues to be, the chief Turkish ensign.

"Well, I must own that you have given me a new and very curious piece of historical information, and I thank you for it," said Mr. Seymour.

"Medals, then, are occasionally of some little use," remarked the vicar, with a sarcastic smile; for if the truth must be told, the reverend antiquary had been a little nettled as usual by the freedom with which Major Snapwell had criticised some of his rarities; but let that pass.

As soon as the party re-assembled after the excursion of the morning, the circumstances which so greatly astonished Miss Villers on the preceding evening, were again related by her.

"My dear young lady," observed Mr. Seymour, "I never heard a better story for illustrating the illusions to which the senses are exposed; and if you will read the second letter on 'Natural Magic,' by Sir David Brewster, you will obtain a ready explanation of your vision—but let us examine it philosophically. In the first place you acknowledge that your imagination had been previously excited during your ramble through the wood, and more especially by your reverie at the statue of Time; now it is well known that such a condition of the mind prepares and adapts the organs of vision for those illusions which I am about to explain. You have told us that, on your descent into the valley, the moon had withdrawn its light, and several minutes had elapsed before an object became visible, and that was the *white* foam of the waterfall."

"If I rightly remember, Brewster has stated that the spectres which are conjured up by the imagination are always *white*, because no other colour can be seen at night," observed Mrs. Seymour.

"Undoubtedly," replied her husband; "and as these spectres are formed out of objects whose different parts reflect different degrees of light, their fainter parts will appear and disappear with the ever varying degree of illumination which is occasioned by the moon shining through a veil of clouds, and a change even of shape will be thus produced which will impart to the object in question the semblance of a living form. The actual state of the eye itself will also greatly assist in completing such an illusion; for, in consequence of the small degree of light, the pupil expands to nearly the whole width of the iris, in order to collect every ray, and in such a condition it cannot accommodate itself to see near objects distinctly, so that the form of a body actually becomes more shadowy and confused when it comes within the very distance at which we count upon obtaining the best view of it."

"You have certainly explained the reason why bodies seen under a faint illumination may appear distorted and caricatured; but I am still at a loss to understand how the vision I witnessed in the valley could have been conjured up," said Miss Villers.

"It was the doubtful and flickering light of the clouded moon upon the mass of white sandstone," said Mr. Seymour. "It is a great law of the imagination, that a likeness in part tends to become a likeness of the whole. The sandstone presented, in the first instance, a form somewhat resembling the human figure, or some part of it, when your active imagination immediately completed the outline; just in the same way as we trace images in the fire, or castles in the clouds, or grotesque figures of men and animals on damp walls." (40.)

"I am satisfied," said Miss Villers, "and I thank you, and Sir David Brewster, for the lecture; and now," continued the lady, "how will you explain the circumstance of my name having been so audibly pronounced, and from a spot which made it impossible that it should have come from any human being."

"It was the solitary spirit of the dell," said Mr. Seymour, with a smile; "a rural spirit who is disposed to become very loquacious whenever the repose of her habitation is disturbed. I can assure you," added he, 'that you are not the first person whom her gambols have surprised and terrified in the shades of evening. I presume you have discovered that I allude to that unseen musician of the air—ECHO."

"Indeed, Mr. Seymour, the sound could not have been the effect of an echo, for I never spoke," replied Miss Villers.

"Very likely, but I happen to know that Mrs Seymour called you by name at the orchard gate."

"Nor will that explain it," observed Miss Villers, "for in that case I must certainly have heard her, whereas the sound came in a very different direction, from the inaccessible rocks of sandstone."

"Young lady," said Mr. Seymour, "you must forgive me for telling you that your philosophy is at fault. It is as possible to hear an echo, without recognizing the direct sound which produced it, as it is for two persons to be so placed as to see each other in a looking-glass, although objects might obstruct the direct view of themselves—but I will hereafter demonstrate this truth by an actual experiment. I now propose to dedicate an hour to the explanation of the several toys which owe their action to atmospheric vibration; I shall then be at your service to interrogate the spirit of the valley; and the children, whom I intend to accompany us, will be thus better prepared to comprehend the theory of the echo.

"Musical instruments, amongst which I include the toys to which I have alluded," said he, "may be classed under three heads:—*stringed* instruments, such as the harp, violin, &c.; *wind* instruments, as the flute and trumpet; and instruments of *percussion*, as the tabor and drum."

"And which kind do you consider the most ancient?" asked Miss Villers.

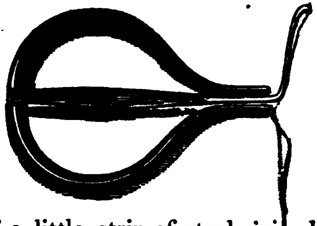
"*Wind* instruments, madam, most unquestionably," cried Mr. Twaddleton. "Diodorus ascribed their invention to the accidental notice of the whistling of the wind in the reeds, on the banks of the Nile; and the poet Lucretius maintained a similar opinion."

"I really, my dear Sir, cannot see any good reason for giving this preference, in point of antiquity, to wind instruments," said Mr. Seymour. "The lyre, or harp, is, surely, as ancient as any instrument on record. The mythologist ascribes the idea of producing sound by the vibration of a string, to Apollo; which is said by Censorinus to have suggested itself to him, on his hearing the twang of the bow of his sister Diana. With respect to instruments of percussion, it may be reasonably supposed that the sonorous ringing of hollow bodies, when struck, must have very soon suggested their invention to mankind; but I really consider any research into a question of such obscurity as uninteresting as it must be hopeless; let us rather devote our attention to the philosophy of these instruments. I have stated that they may be referred to three principal classes; but I must at the same time observe that, in some cases, the vibrations of solid bodies are made to co-operate with those of a given portion of air; for example, trumpets and various horns may be said to be mixed wind instruments, since their sound is produced by the joint vibrations of the air and a solid body; and in certain stringed instruments, as in the violin, the immediate effect of the strings is increased by means of a sounding-board, which appears to be agitated by their motion, and to act more powerfully on the air than the strings could have done alone."

"I apprehend that this mixture must obtain more or less in all instruments," said the vicar.

"Not at all. The flute, flageolet, humming-top, and the cavity of the mouth in whistling may be considered as simple wind instruments, in which the quality of the sound is alone determined by the vibrations of the air. I have already explained the manner in which the oscillations of a string excite aerial undulations, and thus produce sound; and you have seen that the nature of these sounds is determined by the length and thickness of such strings; the theory equally applies to wind instruments, in which case, a column of air corresponds with the string, the volume and length of which determines the sound. In the harp, the strings are constructed of different lengths and dimensions; and so, in the *Syrinx*, or *Pan's pipes*, is the volume of air adjusted to the respective notes by the size and length of the reeds; but, in the violin, the lengths of the strings are altered at pleasure by pressing them down on the finger-board; and, in like manner, the effective length of the flute is changed by the opening or shutting the holes made at proper distances in them; the opening of a hole at any part being the same in effect as if the pipe were cut off a little beyond it."

Mr. Seymour and the vicar then entered into a long discussion, with which it is not our intention to swell our history, or to exhaust the patience of the reader; we shall, however, with his permission, collect from the mass some of the more interesting facts, and present them in as condensed a form as may be consistent with perspicuity. In speaking of the *Jew's harp*, a little instrument with which every school-boy is well acquainted, the vicar stated that its origin was lost in the long lapse of time; but that it was in very common use throughout Europe, and more especially in the Netherlands and the Tyrol, where it was the delight of the peasants and their families. He also said that it was known in Asia, and that the Greeks of Smyrna called it, in imitation of its sound, *biambo*. The name by which it is now known, he observed, was evidently derived from the Jews, who were formerly the great venders of it, and of other toys throughout Europe, although he stated that his friend Mr. Prybabel was of opinion that it was a corruption of *jaw's* harp. Mr. Seymour described its construction, and the theory of its action. It is composed of two parts, the *body* and the *tongue:* the former has some resemblance to the handle of a certain kind of corkscrew; the latter consists of a little strip of steel, joined to the upper part of the body, and bent at its extremity, so that the fingers may touch it more readily. This tongue, or elastic plate, produces, in itself, only a sound which serves as a drone, although it appears to act like the motion of the bow of a violin in exciting other sounds, by breaking the current of air from the mouth, the acuteness or gravity of which will be determined by the pressure of the lips, and the magnitude of the cavity of the mouth. To understand, however, this part of its operation, it is necessary that the reader should become acquainted with the nature and effects of what have been termed *Resonances, and Reciprocated Vibrations of Columns of Air.* This property of sounding bodies, which to the ignorant must appear as an inexplicable species of sympathy, will be more fully explained in a note (41); at present we shall merely give one or two examples of its effects. A singer has been known to break into pieces a large tumbler glass by the power of his voice; and a violin suspended against a wall may be heard to yield the same notes as those produced by a performer on a similar instrument in the same room. To produce such an effect, however, one condition

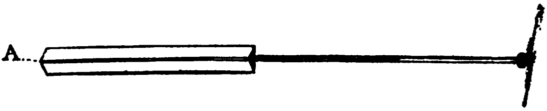


is indispensable, that the body to be put in vibration must be in unison, or agreeing in pitch, with the one communicating the sound. Hence the necessity of so adapting the capacity of the mouth in playing the jew's harp, as to make the column of air which it contains to reciprocate the sound of its tongue. The subject was agreeably concluded by some anecdotes which were related by Miss Villers, in proof of the astonishing powers of this little instrument when directed by the skill of a master. For the sake of those who may be curious upon this subject we have introduced an account of two great performers, in an additional note. (42) In speaking of the flute, Mr. Twaddleton took occasion to observe, that its name was derived from *fluta*, a lamprey, or small Sicilian eel, which has seven holes on each side; an etymology which will probably be as new to our readers as it was to ourselves. The children also received their share of instruction and amusement upon this occasion. Tom, for the first time, became acquainted with the use of the pea in the whistle, which, he was told, was to agitate and break the current of air, and thus to produce a succession of quick vibrations upon which the acuteness of its sound depended. Louisa exhibited her *whiz-gig*, which, for the information of the unlearned reader, we may state to consist of a hollow disc of wood, having an opening in its side, like that in the humming-top; by the alternate coiling and uncoiling of the cord upon which it is strung it receives a circular motion, the rapidity of which produces, by means of its opening, an aerial vibration that gives a loud ringing sound.

"I should very much like to hear your opinion of that Egyptian wonder, the statue of Memnon," said the vicar.

"Its history," answered Mr. Seymour, "is involved in considerable doubt and difficulty. Authors of credit agree in stating that it certainly saluted the rising sun with a musical sound; but doubts are still entertained as to the cause which produced it, whether it was the effect of mechanism, or a juggle of the Egyptian priests. An English traveller, Sir A. Smith, informs us that he visited the statue, and actually heard the sounds at six o'clock in the morning; but he believes that they proceeded, not from the figure, but from the pedestal, and he considers that they may arise from the impulse of the air upon the stones of which it is constructed. Others have supposed that the heat of the sun's rays, concentrated by a mirror, may have acted upon plates of metal so as to produce the effect. It is not my intention to argue this point; but I will show you an experiment, by which you will, I think, be convinced that a statue might easily be constructed like the Memnon to yield musical sounds by the application of heat, whether derived from the solar rays, or from any other source."

Mr. Seymour produced a piece of apparatus, of which we here present the reader with a sketch. It



consists of an oblong block of copper, one surface of which is flat, the other formed by two planes meeting at an obtuse angle, and having a groove at the point of junction. To this block a handle is affixed.

Mr. Seymour having thus described the form of the instrument, and stated that its construction was solely directed with a view of making it oscillate freely on any plane surface, thrust the block in the fire, and when sufficiently heated, placed it, on its angular surface, upon a flat piece of lead. It immediately began to vibrate, producing at first, a kind of singing noise, not unlike that of the simmering of a teakettle, but the vibrations became more and more rapid until a distinct musical sound was produced, which from time to time varied in its pitch, and gave rise to an effect scarcely inferior to that of the Eolian harp."

"How extremely beautiful!" said Miss Villers.

"And how admirably does it illustrate the theory of musical sounds," observed Mr. Seymour. "We have here, you perceive, a series of impulses communicated to our ears by the air, at first in slow succession, and by degrees more and more rapidly; at first we hear a rattling noise, then a low murmur, and then a hum which by degrees acquires the character of a musical note, rising higher and higher in acuteness. It is evident, therefore, from this experiment alone, by showing the correspondence which exists between the pitch of the note and the rapidity of the succession of the vibrations, that our sensation of the different pitches of musical notes originates in the different rapidities with which their impulses are communicated to our ears."

"Pray explain to us the manner in which the block of metal is thus made to vibrate," said Miss Villers.

"It depends," replied Mr. Seymour, "upon the alternate contraction of the two opposite edges of the metal from the loss of heat; one of the edges coming in contact with the cold lead contracts, and by destroying the balance of the block, causes its opposite edge to come into contact with the lead, and to undergo the same change; and it is by this alternate action that a rapid vibration is produced, occasioning, as you will now readily understand, the musical sounds you have just heard."

The lecture having been concluded, Mrs. Seymour proposed that the party should, at once, proceed to the valley, but the vicar suggested the propriety of first explaining to the children the principle upon which the echo depended.

Mr. Seymour concurred in this opinion, and immediately afforded the following explanation:—" An echo is nothing more than a reflected sound. When the aerial vibrations strike against any obstacle of sufficient magnitude, they are reflected back to the ear, and produce a repetition of the sound, which will appear to proceed from the point whence they are reflected, so that the apparent direction of the voice becomes completely changed by an echo. A considerable extent of level wall will sometimes produce it in great perfection; for a smooth surface reflects sounds much better than a rough one: but the circumstance which, perhaps, contributes more than any other to the perfection of an echo, is the form of the reflecting surface; a convex surface is a very bad reflector of sound, a flat one reflects very well, but a small degree of concavity is the form best adapted to the purpose."

" I believe," observed the vicar, " that fluid bodies will also, under certain circumstances, so reflect sound as to produce echoes."

" Undoubtedly. The surface of water, especially at the bottom of a well; and sometimes even clouds will produce this effect."

" Do you mean to say, papa," asked Tom, " that sound is reflected from an obstacle to the ear, in the same manner as my ball is reflected after striking the wall?"

" Certainly: supposing, of course, that your ball is perfectly elastic; and, in that case, you no doubt remember the direction it will follow."

"It will always make the angle of *reflection* equal to the angle of *incidence**," said Tom.

"Undoubtedly; and so it is with sound, since air, as you know, is perfectly elastic. If, therefore, the vibrations fall perpendicularly on the obstacle, they are reflected back in the same line; if obliquely, the sound returns obliquely in the opposite direction, the angle of reflection being equal to that of incidence. You will, therefore, readily perceive," continued Mr. Seymour, addressing his conversation more particularly to Miss Villers, "that a person situated at an appropriate angle may hear an echo, as it is returned from the reflecting surface, without hearing the original sound which produced it. M. Genefay has described, as existing near Rouen, a curious oblique echo which is not heard by the person who emits the sound. A person who sings hears only his own voice, while those who listen hear only the echo."

"As a smooth and concave surface is capable of producing an echo, how does it happen that we so rarely meet with one in a room?" asked Louisa.

"Echoes, my dear, are, in fact, produced in every room, by the reverberation of sound from its walls; but on account of the velocity with which it travels, they are imperceptible in small chambers, because the sound occupies no sensible period of time in moving from the mouth to the walls, and in returning back to the ear again, consequently, the original sound and its echo become so blended and incorporated, as to appear but one sound. As the dimensions of the apartment increase, the defect will increase with it; and, in buildings for music or public speaking, it is often highly inconvenient, and difficult of prevention. Breaking the surface, or rendering it uneven by mouldings and ornaments, appears to be the most effectual method of curing the evil."

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* The reader is requested to turn to page 176; for all that is there said respecting the principle of *reflected* motion will apply to the theory of the echo.

"I perceive then, papa, that in order to produce a perfect echo, the person who speaks must be at a considerable distance from the obstacle that reflects the sound," said Louisa.

"It cannot be otherwise," replied her father; "and if you will only consider the rate at which sound travels, you will readily understand the necessity of such an arrangement. In order to produce a distinct echo of one syllable, or of a single sound, the reflecting obstacle must be at least 70 feet from the sound, so that it may have to pass through a distance of 70 feet to get to the reflector, and 70 more to return to the ear, making a total passage of 140 feet, which it will accomplish in rather less than one-eighth of a second; a period of time so small, that, if it were diminished, it is evident the echo must be assimilated with the sound itself."

"But the echo in the valley," observed Mrs. Seymour, "will repeat four or five syllables."

"Undoubtedly. If we make the experiment at a sufficient distance from the sandstone rocks which act as the reflector."

"It would appear, then, that the farther the reflecting object is off, the greater number of syllables will the echo repeat; and I should think that this fact might enable us to compute the distance of the reflector," said Mrs. Seymour.

"In a moderate way of speaking, about three and a half syllables are pronounced in one second, or seven syllables in two seconds; when an echo, therefore, repeats seven syllables, we may infer that the reflecting object is 1142 feet distant."

"But, my dear Mr. Seymour, this must surely depend upon the nature of the syllables," said the vicar. "Pray excuse the interruption; but you will admit that there must exist a great difference between the echo of dactyles and spondees. Suppose an echo should be able to return ten syllables; thus—

> 'Tityre, tu patulæ recubans—'

I will be bound for it, that if you were to try its powers in slow heavy spondees, as *monstrum horrendum*, a return of not more than four or five syllables could be observed."

"I will not dispute that point," said Mr. Seymour.

Louisa here remarked that she had often heard of some very extraordinary echoes in different parts of the world, to which her father had not alluded; she mentioned, for instance, those which are said to repeat the same sound several times in succession.

"From the explanation which I have already given of the nature of echoes," said Mr. Seymour, "it will be easily conceived that a vast variety of effects may be produced by varying the form, the shape, the distance, and the number of reflecting surfaces: and hence we hear of various surprising echoes in different places. It is not difficult, for instance, to understand the nature of compound, or tautological echoes; in which case the expression of one *ha* will appear like a laughter. Addison mentions an extraordinary instance of this kind near Milan, which will return the sound of a pistol fifty-six times."

"I have understood that the echoes on the lakes of Killarney are of this multiplied description," said the vicar.

"They are particularly calculated to produce reflections of sound, from the height of the mountains, and the expanse of water," replied Mr. Seymour, "which latter circumstance always assists the conveyance of reflected, as well as direct sound. I believe that there is a certain spot on the shore of Ross island, where the sound of a bugle produces an echo which far exceeds any other to be met with amongst the lakes; the first echo is returned from the castle, the second from the ruined church of Aghadoe, the third from Mangerton, and afterwards innumerable reverberations are distinguished, which, like the faded brilliancy of an extremely multiplied reflection, are lost by distance and repetition."

"There is an admirable echo," said the vicar, "behind my old college at Cambridge; and often have I, while walking on the road to Chesterton, on a calm evening, distinctly heard twelve repetitions of the voice. Lord Bacon, if I remember correctly, mentions an instance of sixteen, in some ruined church near Paris."

"It was in the church of Pont-Charenton, on the Seine," replied Mr. Seymour; "in which place that great philosopher discovered the inability of an echo to return the letter S, for having pronounced the word *satan*, the echo replied *va-t-en*, which in French signifies *away;* from which circumstance, the Parisians concluded, that some guardian spirit prevented the walls of the sacred edifice from pronouncing the name of *satan*."

"And will not an echo repeat the letter S?" asked Louisa.

"Not always," answered her father; "the hissing or sibilant noise of the letter, when at the commencement of a word, is generally lost, unless the echo be extremely perfect."

The party now set off on their excursion to the valley. Mr. Seymour disposed them in such situations as were best calculated to display the powers of the echo, and to illustrate the several effects which he had endeavoured to explain. The vicar performed his experiment with dactyles and spondees, and was highly gratified to find that their results proved, in a most satisfactory manner, the correctness of his conjecture. The attention of Miss Villers was particularly directed to the effect of the voice of Mrs. Seymour from the orchard gate, and which, she said, convinced her that the sound she had heard on the preceding evening must have arisen from the cause assigned to it.

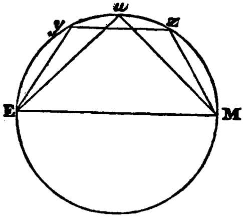
After the party had fairly tired themselves by their converse with the airy and unsubstantial being, they descended to the sandstone rocks, which Mr. Seymour pointed out as the local habitation of the solitary spirit. These were duly examined by Louisa and Tom, and their operation as a reflecting screen was pointed out to them by their father. They now returned into the geological temple; its singularly beautiful pillars very naturally attracted the attention of Miss Villers, and she expressed a wish that Mr. Seymour should describe the plan of their construction; for it was very evident, as she said, from the disposition of the specimens, that the arrangements had been directed with some view to geological illustration. Mr. Seymour felt gratified by this request, and promised to comply with her wishes, as soon as he had finished the investigation of those laws by which the reflection of sound was governed.

"Why, bless me!" exclaimed the vicar, "the revels of our airy companion are ended; and I maintain, that nothing can be more appropriate than the consideration of the objects for which Miss Villers has expressed so much interest. In truth, the history of echo is classically associated with that of geology: by diving into the recesses of the rock, we do but pursue her descent from air to earth; for you, no doubt, remember that after she had been deprived of her loquacity by Juno, she became enamoured of Narcissus, pined away, and was transformed into stone."[*]

"I cannot but admire the ingenuity with which you embellish every subject with classical decorations," replied Mr. Seymour. "You, however, must well know that I require no such allurement on the present occasion. I shall be most willing to afford Miss Villers the information she requires, as soon as I have explained to my young pupils the principle of the whispering gallery in St. Paul's; as well as some recreations which are indebted for their effects to the reflection of sound."

"I ought to apologise for the interruption I have occasioned," said Miss Villers; "but I was not, until this moment, aware of the extent to which you intended to carry your illustrations."

Mr. Seymour commenced with the subject of the "whispering gallery," at the foot of the dome of St. Paul's cathedral; and in order to render intelligible the manner in which sound is concentrated, and thereby magnified in that hollow hemisphere, he produced a diagram, of which the annexed cut is a copy.



He explained it as follows:—

"M shows the situation of the mouth of the speaker, and E that of the ear of the hearer. Now, since sound radiates in all directions, a part of it will proceed directly from M to E, while other rays of it will proceed from M to *u*, and from M to *z*, &c.; but the ray that impinges upon *u* will be reflected to E, while that which first touches *z* will be reflected to *y*, and from thence to E; and so of all intermediate rays, which are omitted in the figure, to avoid confusion. It is evident, therefore, that the sound at E will be much stronger than if it had proceeded immediately from M without the assistance of the dome; for, in that case, the rays at *z* and *u* would have proceeded in straight lines, and consequently could never have arrived at the point E."

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[*] Ovid's Metamorph. 3. 358.

"I have understood that a similar effect may be witnessed in the stone recesses on Westminster-bridge," said the vicar.

"That is the fact," replied Mr. Seymour. "The recesses to which you allude are semi-domes; and if a person whispers in the focus of one of them, he will be distinctly heard by another stationed in the focus of the opposite one. Two inanimate busts may be thus made to appear as if holding a conversation, by placing them in the foci of two large concave mirrors constructed of pasteboard, and arranged opposite to each other; when a whisper uttered to the one will seem to proceed from the other by the reflection of sound."

Mr. Seymour now removed a shell from a group of corallines which decorated a part of the temple, and desired Tom to place it to his ear.

"I hear a noise which appears to me to resemble that of the sea," cried Tom.

"Ay," said the vicar, "and there is a popular belief that it is the murmur of the sea, which the shell actually sends forth, betraying, as it were, its marine origin."

"And what produces the sound?" inquired Louisa.

"The interior of the shell merely concentrates, and thus magnifies the sounds around us, so as to render them audible: a goblet applied to the ear will be found to produce the same effect," replied her father.

"I suppose it is upon the same principle that the speaking-trumpet is made to convey sound to a distance," remarked Louisa.

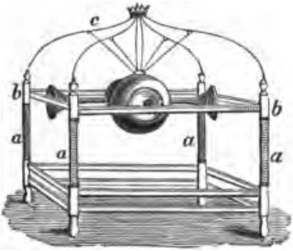
"Since sound radiates in all directions, it follows that, if such radiation be prevented by confining it in tubes, it may be carried to a great distance with very little diminution of its effect; and hence the use and application of those trumpets, or tin speaking-pipes, which are now commonly used for conveying intelligence from one part of a house to another. The trumpet used by deaf persons acts on the same principle; but as the voice enters the trumpet at the large instead of the small end of the instrument, it is not so much confined, nor is the sound so much increased."

"I believe," said Mrs. Seymour, "that the experiment exhibited some time since in London, under the title of the *Invisible Girl*, and which excited such general curiosity, was discovered to depend upon an arrangement of this kind."

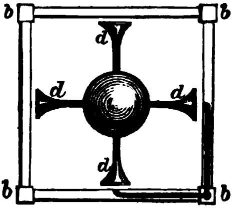
"I expected that you would allude to that exhibition," said Mr. Seymour; "and as I was anxious to provide my young pupils with some new amusement, as a reward for their industry, I have directed Tom Plank to construct the necessary apparatus for exhibiting and explaining the deception. On our return to the lodge, I have no doubt we shall find that every arrangement for the performance has been completed."

Miss Villers was now gratified by a view of the more interesting specimens in the geological temple. Mr. Seymour also explained the design of the pillars which had so greatly excited her curiosity.

On the return of the party, Mr. Seymour found, as he had anticipated, that the necessary apparatus for the experiment of the "Invisible Girl" had been duly arranged, and that Tom Plank was in attendance to afford any assistance which might be farther required. We shall proceed to describe all the visible mechanism, as it appeared to the children on entering Mr. Seymour's study, and of which we here present the reader with a perspective sketch.



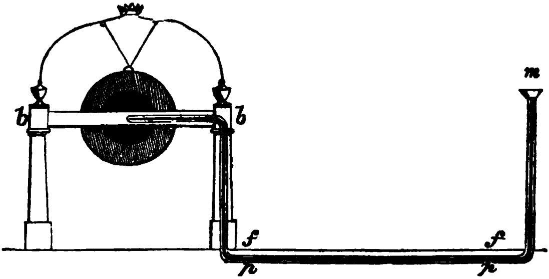
It consisted of a wooden frame, not very unlike a bedstead, having four upright posts, *a a a a*, and a cross-rail at top and bottom to strengthen them. The frame thus constructed stood upon a low table, and from the top of each of the four pillars sprang four bent brass wires, which converged to the point *c*. From these wires a hollow copper ball was suspended by ribands, so as to cut off all possible communication with the frame. The globe was supposed to contain the invisible being, as the voice apparently proceeded from the interior of it; and for this purpose it was equipped with the mouths of four trumpets, placed round it in a horizontal direction, and at right angles to each other, as shown in the annexed section,



in which the globe is represented in the centre: *d d d d* are the trumpets, and *b b b b* the frame surrounding them, at the distance of about half an inch from their mouths. Such as we have described was the apparatus, which had been constructed under the direction of Mr. Seymour, who informed the party that, if any of them would ask a question of his little fairy, and direct the voice into one of the trumpets, an answer would immediately be returned from the ball.

"Let me interrogate her," exclaimed Louisa, as she advanced towards the railing. "Tell me, mysterious being, the name of the person who now addresses you."

"Miss Louisa Seymour," answered a voice sufficiently audible to Louisa, whose ear was near the mouth of the trumpet, and yet so distant and feeble, that it appeared as if coming from a very diminutive being, and thus heightened the deception. Each of the party successively asked some question; and the surprise of the children may be more easily imagined than described. Tom examined the ball, the trumpets, and the framework; but he was unable to discover any clue by which he could unravel the mystery. At length Mr. Seymour proceeded to the explanation. He told them that the mechanism owed its effects to the combined operation of two principles with which they were already acquainted; the concentration and conveyance of sound by means of a speaking-pipe, and its reflection from an appropriate surface so as to change its apparent direction, by producing an artificial echo. He then showed them the pipe which was concealed in one of the legs of the frame, and explained in what manner the voice of Tom Plank, who had been stationed in an adjoining room, was conveyed to the mouth of the trumpet, and thence reflected to the ear of the observer. By means of the annexed section, we shall hope to render this subject as intelligible to our readers, as did Mr. Seymour to his little pupils.



*b b* represent two of the legs of the frame, one of which, as well as half the rail, is made into a tube, the end of which opens immediately opposite to the centre of the trumpet. This hole is very small, and concealed by mouldings; the other end communicates by a tin pipe, *p p*, which passes, in a concealed manner, along the floor of the room, into an adjoining closet, where the confederate is concealed. It is evident that any sound, directed into the mouth of the trumpet, will be immediately reflected back to the orifice of the tube, and distinctly heard by a person who places his ear to the mouth of the funnel *m;* while the answer returned by him, travelling along the tin funnel, *p p*, will issue from its concealed orifice, and striking upon the concave surface of the trumpet, be returned to the ear as an echo, and thus appear as if it had proceeded from the interior of the ball.

The vicar observed, "that this deception of the *Invisible Girl*, which had formerly created so much interest, was little more than the revival of the old and well-known mechanism of the *speaking bust*, which consisted of a tube, from the mouth of a bust, leading to a confederate in an adjoining room, and of another tube to the same place, ending in the ear of the figure; by the latter of which, a sound whispered in the ear of the bust was immediately carried to the confederate, who instantly returned an answer by the other tube, ending in the mouth of the figure, which therefore appeared to utter it. The Invisible Girl," continued the vicar, "evidently only differs from that contrivance in this single circumstance, that an artificial echo is produced by means of the trumpet, and thus the sound no longer appears to proceed in its original direction."

"Your remark is perfectly correct, my dear vicar," said Mr. Seymour.

Tom Plank, with an air of self-satisfaction, at this moment emerged from his retreat, and enquired whether his performance had not met with the approbation of his employer.

"Gentlemen," said Tom Plank, "as I am now fully satisfied that any plan of propelling live and dead luggage through funnels can never succeed, I propose to employ tubes for conveying sounds to a great distance, so as to do away with the use of telegraphs?"

"Why that plan is more practicable, but less novel, than the one you have just abandoned," answered Mr. Seymour. "At the latter end of the last century, a man of the name of Gautier conceived a method of transmitting articulate sounds to an immense distance. He proposed the construction of horizontal tunnels that should widen at their extremities, by means of which the ticking of a watch might be heard more distinctly at the distance of two hundred feet than when placed close to the ear. I think he calculated that a succession of such tunnels would transmit a verbal message nine hundred miles in an hour." (43)

"Only think of that!" ejaculated Tom Plank; "to make a communication from London to Edinburgh in about twenty-five minutes!"

"True, my friend, but what would you say, were I to suggest a method of communicating information to any distance without the loss even of a single second of time." (44)

"There now," cried the vicar, "you have supplied Tom Plank with some fresh barm to set his brains working."

"He is an indefatigable fellow, I must allow," said Mr. Seymour.

The party now dispersed. Miss Villers retired into the drawing-room, to afford Louisa some musical instruction; the vicar took his departure for the sake of visiting a sick parishioner; and Major Snapwell to make arrangements for an important event, with the nature of which the reader will very shortly be made acquainted.

# CHAPTER XVI.

AN INTERESTING COMMUNICATION, FROM WHICH THE READER MAY LEARN THAT THE MOST IMPORTANT EVENTS ARE NOT THOSE WHICH ABSORB THE GREATEST PORTION OF TIME IN THEIR RECITAL.—MAJOR SNAPWELL COMMUNICATES TO MR. SEYMOUR AND THE VICAR, HIS DETERMINATION TO CELEBRATE THE MARRIAGE OF HIS NEPHEW BY A FETE AT OSTERLEY PARK.—AN ANTIQUARIAN DISCUSSION OF GRAVE IMPORTANCE.—AN INTERVIEW WITH NED HOPKINS, DURING WHICH THE WIT DISPLAYED BOTH CUNNING AND HUMOUR.—THE THAUMATROPE.—ITS IMPROVED CONSTRUCTION.—PHILOSOPHY OF ITS ACTION.—ANOTHER OPTICAL TOY.—THE NATURE OF OPTICAL SPECTRA ILLUSTRATED AND EXPLAINED.—THE SPECTRAL CROSS OF CONSTANTINE.

FOR some time had Major Snapwell been occupied in making arrangements for an event, which he hailed not only as the accomplishment of his most ardent wishes, but as the guarantee of his future happiness. We did not think it right to impart this secret to our readers, until the period should arrive when, in conformity with the usage of the world, the subject might be referred to without reserve or impropriety. To such a period has our history arrived, and we shall therefore at once communicate the whole story, by relating the substance of a conversation which took place between Major Snapwell and the Vicar, in the presence of Mr. and Mrs. Seymour, in the library of Overton Lodge.

"Your hand, my dearest friend! your hand, and with it the congratulations of your heart," exclaimed the Major, as he approached Mr. Twaddleton; "our friends here," added he, as he bowed to Mr. and Mrs. Seymour, "are already "acquainted with the proposed union between my worthy nephew, Henry Beecham, and the charming Isabella Villers; and may Heaven shed the dew of its blessing upon them!"

"Amen!" ejaculated the vicar.

"Well, sir, I am most anxious that the ceremony should take place at Overton, and that you should officiate upon the occasion."

"Most cheerfully shall I comply with your request; '*connubio jungam stabili,*' as the immortal poet has it," was the vicar's reply.

"I have also to inform you," continued the major, "that it is my wish to diffuse a portion of that delight, which this event will impart to me, over the neighbourhood in which I shall probably pass the days that may be yet spared to me; listen, therefore, to the plan which I have devised for carrying this into effect. I design to give a public entertainment, upon a plan as novel as its scale shall be extensive; it shall not be a mere blaze of the spirits, but the recreation of the mind, and the jubilee of reason."

"An entertainment!" muttered the vicar, whose countenance afforded any thing but encouragement to such a scheme.

"Ay, vicar; an entertainment which shall be conducted with every regard to ancient usage, and classical correctness," said the major, as he cast a sly glance at Mr. Seymour.

The countenance of the vicar brightened; and he begged his worthy friend to be more explicit, and to state the nature of his intended fête.

"You already know that this boy of mine is shortly to conduct Miss Villers to the temple of Hymen; I would seize that happy occasion for giving a rural fête, in my park, to the inhabitants of Overton and its neighbourhood; and, as there are no less than three events which I am anxious to celebrate, I propose that this same fête shall be continued through three successive days. On the first shall be commemorated the providential escape of my nephew from shipwreck; on the second, his marriage; and on the third, my purchase and occupation of Osterley Park—What think you of my plan?"

"Why, truly, it would admit of much appropriate pageantry, and the arrangement is, doubtless, countenanced by classical authority. Augustus triumphed three days, for the purpose of commemorating three great events; the first of which was the defeat of the Pannonians and Dalmatii; the second, the battle of Actium; and the third, the reduction of Egypt. In the face of such authority, it would certainly ill become me to offer any objection; although, as vicar of the parish, I cannot conscientiously close my eyes against the evils which might possibly arise from such protracted revelry. I would, therefore, with submission, propose that the three events to which you allude should be celebrated by three distinct festivals on one and the same day."

The major saw plainly that the vicar might be made to approve of, or dissent from, any plan, by the dexterous use of classical authority; he therefore determined to use it as a talisman for the accomplishment of his purpose.

"I like your proposition," replied the major, "but I greatly fear that you will not be able to support it by any classical authority; and remember, that every thing must be conducted in the strictest accordance with ancient usage."

"I respect your intention," answered the vicar, "and will immediately search the writings of Lipsius for a precedent; an author who has collected fifteen laws of the Roman entertainments."

Mr. Seymour here interrupted the conversation, by enquiring of the major the plan of those amusements which he proposed to provide.

"I will convert the elm meadow at Osterley Park into a fair," replied the major, "wherein every species of amusement shall be exhibited: I will engage that vagabond Punch, who, like a snail, travels about the country with his house at his back, to display his hereditary wit, and mimic drolleries; tumblers, rope-dancers, conjurors, fire-eaters, and, in short, the whole merry train of Comus, shall be pressed into our service. After these exhibitions, the company may weave the mazy dance, for platforms shall be erected for their accommodation; I will arrange orchestras for music, and ornamented tents for refreshments. The vicar," observed the major, with an arch smile, "shall open the ball with the bride."

"Had I numbered a few olympiads less, major, I might not have declined so flattering a distinction," replied Mr. Twaddleton, evidently not displeased with the compliment.

"Find some classical authority for the measure, and let your age sanction the propriety of my proposal," said the major.

"Your suggestion merits attention—let me see—I have it, major. Socrates learned to dance very late in life, and Cato, with all his severity of manners, disdained not, at the age of sixty, to practise it. I will, therefore, comply with your desire, and certainly lead the bride down the first dance."

"The canal," continued the major, "shall, for the first time, float the proud emblems of British glory on its glassy bosom; and when the shades of evening fall, my Lilliputian ships shall engage—such cannonading! such nautical evolutions!! Mr. Seymour."

"How charming! how very delightful!" exclaimed Louisa and Fanny; "but pray, papa, do allow Tom to return from school to witness all these amusements."

"Fear not," said the major; "I shall make that a condition; and I trust your papa will not refuse the request."

"Certainly not," replied the father; "I shall be anxious to seize so favourable an opportunity for explaining to my children the various tricks they will witness, and the machinery by which the numerous deceptions will be accomplished; thus shall I convert that which, to the common eye, will appear as a scene of idle revelry, into a school of philosophy, and in accordance with my favourite plan, 'turn sport into science.'"

"Upon my word, Mr. Seymour, you are a perfect alchymist, and extract gold from every thing you touch; you have already derived scientific information from the most miscellaneous and trifling amusements, and will, no doubt, upon this occasion, convert our very pies and puddings into instruments of instruction; thus verifying the old adage, that 'there is reason in roasting of eggs,'" said the major.

"I perceive that the major is not aware of the philosophy which suggested that adage," observed the vicar.

"Nor am I," said Mr. Seymour, "and therefore pray enlighten us upon that point."

"You doubtless know that there is a little air bag at the large end of every egg, called the *folliculus aeris*, and which, as we are told, is designed to furnish a supply of air to the growing chick; if, therefore, an egg be exposed to the temperature of hot embers, this air will be suddenly expanded, the shell burst, and its contents scattered into the ashes. To prevent such an occurrence, the careful housewife pricks the blunt end of the shell with a needle, so as to allow the expanded air to escape, and thus to prevent the accident I have just explained; from which it appears that there is reason, or philosophy, in roasting an egg."

"Capital, upon my word," exclaimed Mr. Seymour.

"Well, but papa, we have interrupted the major in his delightful description; he had not concluded the account of his proposed fête," said Louisa.

"Pray go on," cried Fanny: "let me see, where did you leave off? Oh, I remember, you were interrupted in a temporary tent, which I hope you intend to decorate with garlands."

"Leave all that to the vicar, young lady; he will, no doubt, display his classical taste in the emblematical appointments."

"I shall terminate the festivities of the day by a grand display of fireworks; the arrangements of which will necessarily fall under my own more immediate direction. The vicar," added the major, "will perhaps allow me to proclaim him as master of the revels; for he is, as we all well know, deeply versed in ancient customs, and I am especially anxious that every department should be conducted with classical taste."

"I willingly accept the office," said Mr. Twaddleton, with a gracious smile, "since there is authority for my acquiescence. The Romans, in their entertainments, usually appointed a person whom they styled king, and held responsible upon such occasions. I accept it also, on a different ground; that my presence may check the enthusiasm of the people, and restrain the hilarity of the evening within the boundary of rational decorum."

"If in the arrangement of your banquet, my assistance can prove of any service, command me," said Mrs. Seymour.

"Believe me sincere, my dear madam, when I say, that the kind manner in which you receive my plan, and offer to promote its execution, affords me the highest gratification ; if I decline your services, it is only from a fear of usurping the sovereignty of our master of the ceremonies," replied the major.

"What! would you call upon me to marshal the dishes? Am I, at once, to hold the offices of '*Dapifer*,' '*Lardrenius*,' '*Magister Coquorum*,' and *Prægustator?*'" cried the horrified vicar.

"Have I not declared that every part of my entertainment shall be strictly classical? and ought not each dish to convey some moral device, some allegorical design? Are we to feed with as little discrimination as the dogs that devoured the sacred Apis?"

The knowledge which the reader must have already collected of Mr. Twaddleton's character will have satisfied him that, in every action of his life, he was more or less influenced by the spell of ancient authority; but we doubt whether he may not yet have to learn the extent to which the reverend gentleman carried this enthusiasm. We shall, accordingly, beg to state a few instances, which will serve to illustrate this circumstance. Be it known, then, that the very first act which announced the preferment of the Reverend Peter Twaddleton to the dignity of Vicar of Overton, was not, as some might suppose, an increased rate of compensation for the tithes; nor was it a rate levied for the repairs of his house; but the removal of the vane from the spire of the church, which, as it consisted of a simple cross piece of iron, seemed to the vicar's imagination to be wriggling about, without any consciousness of its ancient origin and dignity of descent. He therefore, at his own expense, replaced it by the figure of a cock, which he caused to be duly executed after an authentic model. It will be remembered that the crowing of the cock warned Peter; for which reason the monks first placed the figure of that bird on their churches, as an emblem to call the people to prayers; and, since the image was made to revolve with the wind, it soon acquired the name of a *weather-cock*. With respect to the arrangement of his table, he displayed an equal veneration for ancient forms. He perpetuated the use of the wassail bowl, which was scrupulously prepared with apples and ale, according to the most orthodox receipt. His mince-pies at Christmas were fabricated with the same inflexible adherence to ancient authority; he maintained that the introduction of meat into their composition was a scandalous heresy; that the choicest productions of the East ought alone to be admitted, since the custom was originally intended to allegorise the offerings made by the wise men who came from afar to worship, bringing *spices*, &c. He was also as critical with respect to the *shape*, as he was with regard to the *composition* of these dainty inventions; he insisted upon the ancient or coffin shape, which he stated to have been in imitation of the cratch, or manger, wherein the infant Jesus had lain. His table was, with the same antiquarian correctness, punctually supplied at Easter with a gammon of bacon; a custom, which would, perhaps, have been more honoured in the breach than in the observance, since it was evidently founded on the abhorrence our forefathers thought proper to express towards the Jews, at the season of commemorating the resurrection.* The idea was in direct opposition to the liberal sentiments of the vicar, but, being an ancient custom, he never ventured to question its propriety. In like manner, his tranquillity would have been sadly disturbed, had Annette ever forgotten the *pancakes* on Shrove-

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* Drake's Shakspeare and his Times.

Tuesday; for he was decidedly of opinion that it was a dish which had derived its origin from the heathen Fornacalia, a festival instituted by Numa,* in honour of the goddess Fornax; and was intended to commemorate the making of bread before the invention of ovens. Upon the subject of cross-buns he displayed great profundity; he observed, that the word *bun* was derived from *boun*, a species of sacred bread described by Hesychius, and which was anciently offered to the gods; in support of which opinion he quoted Julius Pollux and Diogenes Laertius; nor did he relinquish the subject, until he had ably descanted upon the address with which heathen customs had been, as it were, naturalized, and perpetuated as Christian observances. The *boun*, he would say, lost its idolatrous impurity by receiving the sign of the cross; in the same manner that Druidical idols, and *stones erect*, by having crosses cut upon them, continued to receive a justifiable reverence, even as late as the seventh century.

In short, the extent to which our excellent but eccentric vicar was carried, on such occasions, can scarcely be credited, except by those who are acquainted with the extravagant whimsies of a genuine antiquary. We have never contemplated this part of his character without congratulating the rising generation at Overton on the circumstance of the offices of village schoolmaster and vicar of the parish not having centered in the same individual; for we have not the shadow of a doubt, so great was his veneration for ancient usages, but he would have whipped up every child within his jurisdiction, on the morning of Childermas-day, or that of the Holy Innocents, as we are informed was the ancient custom, "in order that the memorial of Herod's murder of the Innocents might stick the closer." Whether, in spite of the censure and remonstrance of St. Austin, he would have ventured to continue the half-holiday on a Thursday, it is difficult to say; although the high antiquity of a custom originally established in honour of Jupiter would, doubtless, have produced its influence upon the judgment of the antiquary.

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* Ovid. Fast. 2. v. 525.

We have thought it right to relate these few anecdotes, in order to vindicate the propriety of the major's election, and to convince the reader that a better qualified master of the ceremonies could not possibly have been provided. Having, therefore, payed this homage to the judgment of the major, and to the antiquarian lore of the vicar, we shall return to the party, whom we had rather abruptly quitted, and continue our relation of the conversation which followed.

"So, then, you have determined that the vicar shall superintend the banquet," said Mrs. Seymour. "There is, however, one part of the ceremony which I shall certainly not feel disposed to resign into his hands, the ordering and disposition of the bridal cakes; the genius of Gunter shall be invoked to produce one of the most triumphant specimens of his art."

"Psha, nonsense; you surely would not countenance that ice-clad mountain, through whose dark regions the demon of indigestion holds undisputed sway."

"Why, zounds, vicar, do you expect me to submit to such vagaries?—a wedding without a cake!—it cannot be tolerated." I shall next hear of an English feast without roast beef," vociferated the major.

"You shall, doubtless, have your cake; but let it be the true Roman bride-cake, made after the receipt which Cato has given in his work, *De Re Rustica*, chapter 121. You must be aware, Mr. Seymour, that the *mustacea* of the Romans, the species of cake used at weddings, consisted of meal, aniseed, cummin, and several other aromatic ingredients."

"And do you seriously believe that any of us will swallow such a medicated farrago?" said the major.

"The unenlightened may, perhaps, refuse it; and should the children prefer your modern combination, they might stand excused, since classical inspiration rarely descends upon a boy, until he has construed a Greek chorus," observed the vicar.

"Were I to swallow a grain of it," said Mrs. Seymour, "I verily believe I should be ill for a week."

"Mere prejudice, madam; the object of the *mustacea* was actually to remove or prevent the indigestion which might be occasioned by eating too copiously at the marriage entertainment; and it must, I think, be acknowledged that the compound was better adapted for such a purpose than the modern bride-cake, to which it gave origin."

"With respect to the *roast beef*, to which the major has just alluded," continued the vicar, "I shall only observe, that it was not until the reign of Henry VIII. that it appears to have taken its part in the formation of our national character."

"I would beg to enquire to whom the selection and arrangement of the comic entertainments are to be entrusted. Unless the major should have already found a competent person, I think I can recommend to his notice an individual who is eminently qualified for the duties," said Mr. Seymour.

"I am, at this moment, in quest of such a director," said the major.

"Ned Hopkins, then, who has for some time past taken up his abode at our village alehouse, is the very person, of all others, whom you seek. I have no doubt that for a trifling consideration he will undertake the office; and I feel equally confident that he will execute its duties to your satisfaction."

"Ned Hopkins!" exclaimed the vicar, with some surprise.

"To be sure; and who better understands the trim of those itinerant sons of Comus? Was not his father a mountebank doctor, and a professor of the art of legerdemain?"

"I value not Ned Hopkins the less on that account; the immortal Virgil was the son of a servant, or assistant, to a wandering astrologer, or 'Medicus Magus,' as Juvenal has it. But my dislike to Ned Hopkins is founded upon his own dissipated habits, his total disregard of all decorum, his disgusting jokes, and Bacchanalian buffoonery."

"Ay," continued Mr. Seymour, "and his bad puns, vile quotations, and hackneyed proverbs; and yet you must confess that, after all, he is a very clever fellow."

"Sir," observed the vicar, "Satan does not usually select a fool as his ambassador."

"Upon my word, gentlemen, this must needs be a very amusing fellow, if only one half of the offences charged against him be true; and you have so far excited my curiosity, as to make me desirous of hearing something farther of his history and habits," said the major.

"He is one of those loose spirits," replied Mr. Seymour, "who live upon expedients; and measuring their consciences by their wants, derive a revenue from sources, of which those who jog on quietly through the beaten paths of life have not the most remote conception. He commenced his career under the tutelage of the first fire-eater of the day, but having clumsily scalded his mouth, he lost his reputation, and found it advisable to seek some other stage for the display of his abilities. Possessed of a very considerable degree of native humour and caustic shrewdness, he engaged himself as a 'mercenary,' or literary drudge, to a popular publisher of comic song books, sanguinary murders, magical magazines, amorous valentines, oracles of health, and plans for the liquidation of the national debt; which occupations have, as I have been credibly informed, produced for him during a successful season, some twenty or thirty pounds in the lawful coin of the realm: but Ned, like many a great genius, was better pleased with an hour of idleness than a week of study; and, strange to say, would at any time have preferred a cup of wine to a bucketful of the finest water from Helicon; no sooner, therefore, had he collected a few pounds, than he descended from his high literary station, a lofty garret; and, taking up his abode at some hedge alehouse, would enjoy a life of happy leisure, until every particle of that worldly substance which he had gained by inspiration from above, was gratefully returned to the skies in the form of tobacco fumes. For some months past," added Mr. Seymour, "he has been a constant resident at the Bag of Nails, where, as I am led to believe, he pays for nothing but his tobacco; the worthy hostess having found him a very profitable bait for customers, is too willing to barter the drippings of the kitchen for his wit, and the leakage of the tap-room for his songs."

"I am very curious to become acquainted with this comical being," said the major.

"Suppose we walk into the village," said Mr. Seymour; "we shall be certain of finding him smoking his pipe on a bench before the alehouse door; where he is as regularly stationed by his patroness, to catch customers, as the saucer of treacle is placed in the window of a pastry-cook to attract flies."

"You will excuse my accompanying you," cried Mr. Twaddleton; "I cannot encounter his gross jokes and bad grammar."

The gentlemen accordingly directed their route through Forest Lane, and took leave of the vicar at the entrance of the churchyard. On arriving within twenty yards of the public-house, Mr. Seymour noticed a column of smoke which curled in wreaths about its porch. "There sits Ned," cried he; "I knew we should find him at his post."

"Hopkins! Hopkins!" cried Mr. Seymour, "I fear you have not taken the worthy vicar's advice."

"An old dog cannot alter its way of barking, sir; nor is it easy to straight in the oak the crook that grew in the sapling."

"I am to presume, then, to speak courteously, that you are still 'a man of leisure.'"

"Ay, verily am I; as idle, sir, as a chimney in the dog-days," replied the wag of the tap-room.

"That, by the by, is not a very happy simile of yours, when applied to a man who is *smoking* all day long," observed Mr. Seymour.

"I admit it," said Ned, "so here's another for you,—as lazy as Ludlam's dog, that leaned his head against the wall to bark. But, after all, Mr. Seymour, a day of leisure is to me a golden age, and I am of my Lord Peterborough's way of thinking, who used to say, 'a golden age was that in which every one might *pipe* when and where he pleased.'"

The wag, at this instant, gave such a practical illustration of his theme, as would have suffocated the major, had not his military habits rendered him smoke proof.

"In short, gentlemen," continued Ned, "a pipe is the solace of my life and the mainspring of my spirits; knock out my pipe, and you knock out my brains. I verily believe that, if I could not obtain the 'furies' frankincense,' as they have been pleased to call tobacco, I should be like Vicar Breedon, who, according to William Lilly, cut the bell-ropes and smoked them." So saying, he gave another puff, and then removing the pipe from his mouth, sang the following ditty:—

"Little tube of magic power,
Charmer of an idle hour,
Object of my warm desire,
Lip of wax, and eye of fire;
And thy snowy taper waist,
With my finger gently braced."
&c. &c.

"Always merry, Ned," cried Mr. Seymour.

"Lord bless you, sir, what is life but a jest? I jest to live, and I live but to jest. And so I shall continue to do, until I am put to bed by the shovel."

"Your father was a reputed jester, was he not?" asked Mr. Seymour.

"He was, God bless his memory! and it was his constant prayer that his son Neddy might turn out as sharp a man as his father; and if there be any truth in the adage that 'dogs bark as they are bred,' I certainly had as good a chance of success as most people. Momus rocked my cradle; I ate fire before I was seven years old; and so anxiously did my father superintend my education, that he never suffered me to cut a morsel, until I had cut a joke. 'Neddy,' he used to say, 'I perceive you are like my bagpipes, never audible except your pouch is full of wind; for after a good meal you are as mum as a mouse in a mill; so remember, my lad, no joke no pudding.' Thus schooled, I became, through necessity, a wit, and earned every mouthful by a pun; in short, after a little time, my genius illumined every dish, and, like the fire of London, blazed from Pudding Lane to Pie Corner."

" And you afterwards appeared on the stage, as a candidate for popular applause, which you were fortunate enough to obtain; how came you to desert your calling?" said the major.

" He who licks honey from thorns pays too dearly for it," replied the wit. " So I packed my wardrobe in a pocket handkerchief, and trudged off to Cockneyshire."

" And what was your object?" asked the major.

" To carry my wit to a better market; and instead of retailing it at country fairs, to offer it wholesale to some of the great publishers, from whom I immediately received considerable orders. The profit which rewarded my poetry soon convinced me, notwithstanding all that had been said to the contrary, that there were still some gold mines in Parnassus. I lived for the first week on liquid blacking; and have, ever since, hailed it, as the stream upon which I first launched my little bark, with all the grateful feelings of early associations. I well remember it was winter, and although I contrived by my eulogies of the jet polish, to obtain a diurnal meal from a neighbouring chop-house, I was compelled to sit in my chamber at night without fire or candle, until the publication of my song '*Ah let my muse a flame inspire*' lighted a cheerful blaze in my grate, and enabled me to purchase three pounds of rush-lights. In short, gentlemen, without exhausting your patience with a long recital of my adventures, suffice it to say, that I have always been able to keep my pipe smoking by my *puffs*, my pot boiling by the ebullition of my wit, and my grate blazing by the *fire* of my genius; while paste and scissors never failed to secure a constant supply of *cabbage*, upon which I have thrived like any caterpillar."

Here Hopkins returned to the porch, and took a draught as deep as ever Bitias drank.

"Did I not say," resumed the wag, "that my pipe was the nurse of wit? I ought to have called her the dry nurse. It is a hard case, gentlemen, but I am in the situation of the flying-fish, incapable of keeping myself up, unless I occasionally moisten my wings."

"If you persist in this dreadful habit," said Mr. Seymour, "you will assuredly destroy the coat of your stomach!"

"The *coat* of my stomach!" replied Ned, "if that is all, my stomach must even be contented to do what its master has so often done before it—go in its *waistcoat*, with the understanding that it shall have an additional glass to keep it warm. The stomach had better give up its *coat* than its master be forced to give up his *habit*."

"But suppose I could prove, that by giving up this system, you would lengthen your days," observed Mr. Seymour.

"Lengthen my days,—you are quite right, Mr. Seymour; being rather low in cash, I was compelled to forego my comfort for one whole day, and it was the longest day I ever knew in my life; you are quite correct, Sir."

"You are incorrigible, Ned. But come, what say you to a profitable engagement?" asked Mr. Seymour.

"Why, as to that, Sir, I have always a ready mouth for a ripe cherry."

"You must know, then, that my friend, Major Snapwell, proposes to give a grand rural fête to the inhabitants of Overton; and, as he intends to convert his grounds into a fair upon the occasion, he is desirous of finding some person acquainted with comic entertainments, who would undertake the office of manager, to contract with the necessary performers, and superintend all the arrangements."

"I am the lad for the major's silver," said the delighted wag; "for without vanity, I may say that few persons better understand the art of mixing up the motley ingredients of fun and frolic; there is, besides, that in the major's face which I would willingly call master."

"And were I to judge from your frontispiece of a face," said the major, "I should say that every day in your calendar was a red-lettered one—the painting of that red nose of yours must have cost a trifle."

"Cannot tell; it is not yet finished," retorted the wit.

Major Snapwell, with the assistance of Mr. Seymour, now entered more fully into the nature and extent of the exhibitions which he wished Hopkins to provide; but as he was, at present, unable to fix the exact period for the fête, he directed him to take such steps only, as might be necessary for securing the performers, and to hold himself in readiness for active service.

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# CHAPTER XVII.

THE THAUMATROPE.—A GREAT IMPROVEMENT EFFECTED IN ITS CONSTRUCTION. — ANOTHER TOY UPON THE SAME OPTICAL PRINCIPLE.

Tom's holidays were now drawing to a close, and the children were summoned into the library to receive their last lesson in philosophy.

"You have lately witnessed an experiment," said Mr. Seymour, "which must have convinced you how liable the ear is to be deluded with respect to the nature and direction of sound; I shall now show you that the eye has also its sources of fallacy."

"If you proceed in this manner, you will make us all Cartesians,"* exclaimed the vicar.

"I shall illustrate my subject by means of a new toy, which," said Mr. Seymour, "unless I am much mistaken, will afford as much amusement to the elder as to the younger members of our party, although the vicar may perhaps regard it as a more hostile instrument than even that of the wooden horse which filled unhappy Troy with an armed enemy. It is a small machine," continued Mr. Seymour, "which is well calculated to furnish us with some capital puns."

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* The Cartesians maintained that the senses were the great sources of deception; that every thing with which they present us ought to be suspected as false, or at least dubious, until our reason has confirmed the report.

"With puns!" exclaimed the horrified vicar, who no sooner heard this appalling declaration, than like another Laocoon, he deprecated the introduction of the "*donum exitiale*" within the walls of Overton Lodge. But his hostility was soon disarmed, not by the circumvolutions of a snake around the body of the enraged orator, but by the embraces of little Rosa, who threw her arms around the neck of the vicar, with such supplicating grace, that at length he exclaimed, "Well, well; if it be the decree of the fates, I must submit."

During this altercation, Mr. Seymour had procured the "wooden engine" from his study.

"I will first," said he, "exhibit the toy in its original state, and then show you the improvements which have been effected in it."

"Let us hear the account of its operation," said the major, "which I perceive is enclosed within the box."

"True," replied Mr. Seymour; "and its inventor has given a very plausible explanation of its effects."

"Plausible," muttered the vicar, "plausible enough, no doubt; oh the Sinon!"

Mr. Seymour then proceeded. "This toy is termed the THAUMATROPE."

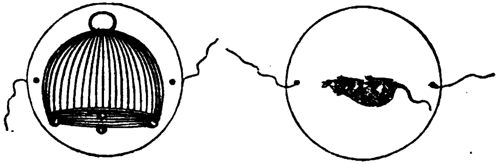
"Of Grecian origin!" observed the vicar. "'*Timeo Danaos et dona ferentes*,' as Virgil has it."

"What is the meaning of the term?" asked Louisa. The vicar explained to her that it was compounded of the Greek words, *θαυμα*, and *τρεπω*; the former of which signified *wonder*, the latter *to turn*."

"Exactly," replied Mr. Seymour. "'*A Wonder-turner*,' or a toy which performs wonders by turning round: but let me proceed in the explanation." He then continued to read as follows: "This philosophical toy is founded upon the well-known optical principle, that an impression, made on the retina of the eye, lasts for a short interval, after the object which produced it has been withdrawn. During the rapid whirling of the card, the figures on each of its sides are presented with such quick transition, that they both appear at the same instant, and thus occasion a very striking and magical effect. On each of these cards a device is introduced, with an appropriate motto, or epigram; the point of which is answered, or explained, by the change which the figure assumes during the rapid whirling of the card."

"It may be very clever," said the vicar, "but I do not understand it."

"But you shortly will; look at one of the cards." Mr. Seymour then displayed a pasteboard circle, on the one side of which was figured a rat, and on the other, a cage; two strings were fastened in its axis, by which the card could easily be made to revolve, by means of the thumb and finger. Fearing that some of our readers may be as dull of comprehension as the vicar, we have introduced a sketch of the apparatus, in which both sides of the card are exhibited, with the strings by which it is whirled round.



No sooner had Mr. Seymour put the card in motion than the vicar, in a tone of the greatest surprise, exclaimed, "Magic! magic! I declare the rat is in the cage!!"

"And what is the motto?" asked Louisa.

"Why is this rat like an opposition member in the House of Commons, who joins the ministry?" replied Mr. Seymour.

"Ha, ha, ha!—excellent!" cried the Major, as he read the following answer: "because by *turning round* he gains a snug birth, but ceases to be free."

"The very reverse to what occurred in ancient Rome, where the slave became free by turning round," observed the vicar.

The vicar, no doubt, alluded to the custom of making a freeman, as described by Persius; from which it appears, that the clapping a cap on the head, and giving him a turn on the heel, were necessary circumstances. A slave thus qualified became a citizen of Rome, and was honoured with a name more than belonged to any of his forefathers, which Persius has repeated with a great deal of humour in his 5th satire:—

> "—— Heu steriles veri, quibus una Quiritem
> Vertigo facit!"
>
> "That false enfranchisement with ease is found;
> Slaves are made citizens by turning round."
>
> DRYDEN.

"Show us another card," said Tom, eagerly.

"Here then is a watch-box; when I turn it round, you will see the watchman comfortably sleeping at his post."

"Very good! It is very surprising," said the vicar."

"Yes," observed the major; "and to carry on your political joke, it may be said that, like most worthies who gain a post, by *turning round*, he sleeps over his duty."

"The epigram which accompanies it is not deficient in point," said Mr. Seymour.

"The caprice of this watchman surpasses all bounds;
He ne'er sits in his box, but when going his *rounds*:
While he no sooner rests, 'tis a strange paradox!
Than he flies from his post, and *turns* out of his box."

"What have you there?" exclaimed the vicar; "arms and legs, without a body?"

"Yes," replied Mr. Seymour; "and which, on turning round, will present the figure of a king, invested with all the insignia of royalty."

"It is indeed a king. Look at his crown and sceptre!" cried Louisa.

"Now for the epigram," said the major, who then read the following lines:—

"Head, legs, and arms, alone appear;
Observe that no*body* is here:
Napoleon-like I undertake
Of nobody a king to make."

The next card presented a laughing face, which on being turned round, was instantly changed into a weeping one. The motto—*The sweetest things turn sour.*

"The device is capital," exclaimed the vicar, "I question whether Peter of Cortona ever produced a more striking metamorphosis."*

The other cards were now exhibited in succession, of which the box contained eighteen, and the whole party, not even excepting the vicar, were highly gratified with the amusement.

"But I have not yet read to you the author's address to the public; and which, I must say, contains a succession of very happy puns."

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* Ferdinand, Duke of Tuscany, was once struck with the picture of a child crying; the artist, (Peter of Cortona) who was at work upon the head, wishing to give a proof of his skill, by a few judicious touches converted the crying into a laughing face. The Duke was in astonishment; the painter to show himself master of the human countenance restored his first touches, and the Duke again saw the child weeping.

"Spare me! spare me!" cried the vicar: "I like your toy, but cannot discover the advantage of alloying amusement with such spurious wit, and of associating science with buffoonery."

Mr. Seymour, however, was relentless, and thus proceeded: "It is well known that the Laputan philosopher invented a piece of machinery, by which works could be composed by a mechanical operation; and the Quarterly Review has asserted, that a certain English poem was fabricated in Paris, by the powers of a steam-engine; but the author of the present invention claims for himself the exclusive merit of having first constructed a hand-mill, by which puns and epigrams may be *turned* with as much ease as tunes are played on the hand-organ, and old jokes so *rounded* and changed, as to assume all the airs of originality. The inventor confidently anticipates the favour and patronage of an enlightened and liberal public, on the well-grounded assurance, that '*one good turn* deserves another;' and he trusts that his discovery may afford the happy means of giving activity to wit that has been long *stationary;* of *revolutionising* the present system of *standing* jokes, and of putting into *rapid circulation* the most approved bon-mots."

"Why, vicar, what ails thee?" exclaimed the major.

"Our subject has given him a *turn;* let him alone, and he will soon *come round,*" observed Mr. Seymour.

The whole party, with the exception of Mr. Twaddleton, laughed heartily; the vicar, however, did not relax a feature of his countenance.

As soon as this ebullition had subsided, the major enquired of Mr. Seymour, what was the nature of the improvement to which he had alluded.

"My proposed improvements refer both to the subjects, exhibited on the cards, and to the mechanism by which their changes are effected," replied Mr. Seymour.

"In the first place, it has occurred to me that this amusing toy might be made instrumental in impressing classical subjects upon the memory of young persons."

This observation delighted the vicar, who said that he would patronise such an attempt with all his heart.

"Why can we not," continued he, "thus represent the Metamorphoses of Ovid; or what say you, vicar, to converting the fleet of Æneas into sea-nymphs, as Virgil has it?"

"An elegant thought! upon my word; a most elegant conception!" exclaimed Mr. Twaddleton.

"What have we here?" interrupted the major, who had, for the first time, noticed the superscription on the cover of the box: "had I seen this before, I should have augured favourably of the toy: it is like the sign of an inn, which is held out to announce good entertainment within." He then read the following:—

The Thaumatrope;
being
Rounds of Amusement,
or
How to please and surprise
By Turns.

Mr. Seymour now proceeded to explain more fully the optical theory of the instrument, which neither Louisa nor Tom could, as yet, thoroughly understand.

He told them that an object was seen by the eye, in consequence of its image being delineated on the retina, or optic nerve, which is situated on the back part of the eye; and that it had been ascertained, by experiment, that the impression which the mind thus receives, lasts for about the eighth part of a second, after the image is removed. "It is, therefore, sufficiently evident," said Mr. Seymour, "that if any point, as a lighted stick, be made to revolve, so as to complete the circle in that period, we shall not see a fiery point, but a fiery circle; because the impression made by it in every point of its circuit will remain until it comes round again to the spot from which it set out;—but we will, at once, exemplify this fact by an experiment."

Tom was accordingly directed to procure a piece of stick and a candle; and as soon as they were brought into the room, Mr. Seymour ignited the end of the stick, and whirled it round, when a bright circle, without any intervals of darkness, was seen by the whole party.

"Never until this instant," exclaimed the vicar, with an expression of high satisfaction, "did I fully appreciate the beauty of that passage in Milton, wherein the poet evidently describes the rapidity of Satan's flight, as well as the refulgence of his appearance—

" 'Sprung upward like a pyramid of fire.'

"Now to take in the full meaning of this figure," continued Mr. Twaddleton, "we must imagine ourselves in chaos, and that a vast luminous body is rising near the spot where we may be supposed to be standing, so swiftly as to appear a continued track of light, and lessening to the view, according to the increase of distance, until it ends in a point, and then disappears; and all this must be supposed to strike our eye at one instant."

"It is very probable," said Mr. Seymour, "that the poet had such an idea in view, and that he intended by it to convey the immense rapidity of Satan's flight. Homer makes use of the same figure to express the velocity of the javelin, δολιχοσκιον εγχος, the '*long shadowed*' javelin. We shall have ample proof of the effect of this power in the eye of retaining impressions, and of thus converting points into lines and circles, during the exhibition of your fireworks; and which, in fact, derive the greater part of their magical effect from it."

"The pin wheel is certainly nothing more than a fiery circle produced by the rapid revolution of a jet of flame," said the vicar.

"And the rocket," added Mr. Seymour, "is a column of light occasioned by the same rapid movement of a burning body in a rectilinear or curved direction."

"I perfectly understand all that you have said," observed Tom.

"Then you will not have any difficulty in explaining the action of the Thaumatrope, for it depends upon the same optical principle; the impression made on the retina by the image, which is delineated on one side of the card, is not erased before that which is painted on the opposite side is presented to the eye; and the consequence is, that you see both sides at once."

"Or, you might put it in this way," said the major: "that as the image remains the eighth of a second on the retina, after it has been withdrawn from the eye, a revolution of eight times in a second will secure its uninterrupted continuance."

"On turning round the card," observed Louisa, "I perceive that every part of the figure is not equally distinct."

"Because every part of the card does not revolve with the same velocity," said her father; "and this fact offers a good illustration of what I formerly stated,[*] that in circular motion, the parts more remote from the axis of rotation are those which move with the greater velocity. This toy will also be found capable of exemplifying another truth to which I have before alluded, that 'the axis of motion remains at rest while all the parts revolve round it.'"*

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[*] Page 163.

"I remember that very well," exclaimed Tom.

"Then take the card, and spin it between yourself and the window, and tell me what you observe," said his father.

"I see a dark line across the window; and what is very strange, the other parts of the card appear transparent; for they do not obstruct the view of the window, as they would if the card were at rest."

"The dark line you see is the axis of rotation, which being stationary, necessarily excludes the light; the other parts being in motion do not remain a sufficient time to obliterate the image made on the eye by the window. It is true that the card disc passes between your eye and the light, but as it does not continue at any one point for more than the eighth of a second, there is no more apparent intermission of the light than what occurs during the winking of the eyes."

"You allude to a very curious fact," observed the vicar, "that, although we are perpetually covering the eyeballs with our eyelids, we are not conscious of the intervals of darkness."

"The reason of which must surely be obvious from the explanation I have just offered," said Mr. Seymour: "the sensation of light is not exchanged for that of darkness in so short a period as the twinkling of the eye."

"I admit the plausibility of your theory," said the vicar; "but it appears to me that objects frequently linger on the sight for a longer period than that which you assign to them. I well remember seeing the flame of a candle for several seconds after it had been suddenly withdrawn from the apartment."

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* Page 50.

"I admit that strong lights frequently continue for some time thus visible in the 'mind's eye;' and it is well known that such impressions are often followed by images of similar shape, but of various colours. In passing from sunshine to a dark room, we frequently witness the appearance of stars and circles of vari-coloured light; but this phenomenon is very distinct from that of the Thaumatrope, and is to be explained upon very different principles."*

"I know exactly to what you allude," said the major: "and I do not doubt but that many of those illusive appearances, which have been described, might be referred to the operation of the same natural cause. It is easy to imagine that a person who has steadfastly fixed his eyes upon an illuminated object, may, for some minutes afterwards, see the same figure in shade; it was from such a cause, no doubt, that Constantine saw the image of a cross in the sky. You are, probably, acquainted with the opinions of Eusebius, Fabricius, and Dr. Lardner, upon this alleged miracle."

"Sir David Brewster, in his late work on Natural Magic, has given us a beautiful illustration of the same principle; it is as follows," said Mr. Seymour. "A figure dressed in *black* and mounted upon a *white* horse, was riding along exposed to the bright rays of the sun, which through a small opening in the clouds was throwing its light only upon that part of the landscape. The *black* figure was projected against a white cloud, and the white horse shone with particular brilliancy by its contrast with the dark soil against which it was seen. A person interested in the arrival of such a stranger, had been for some time following his movements with intense anxiety; but upon his disappearance behind a wood, was surprised to observe the spectre of the mounted stranger in the form of a *white* rider upon a *black* steed, and this spectre was seen for some time in the sky, or upon any pale ground to which the eye was directed."

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* Those who are desirous of gaining farther information upon this subject may consult the chapter on "Ocular Spectra, or Accidental Colours," in Brewster's Natural Magic, p. 21; and Edinburgh Encyclopædia, Art. Accidental Colours.

"I cannot understand why the spectre should be opposite in colour to the real image," observed Tom.

"It is a law of vision which you must for the present take for granted," answered his father; "that such is the fact, however," continued he, "I will satisfy you by a very simple experiment."

Mr. Seymour here placed three different coloured wafers in a triangular form on a piece of white paper, and instructed his son to fix his eyes steadily upon them for a minute; this having been performed, he next directed him to turn them from the wafers to a blank part of the paper, and to tell him what he saw.

"I see," exclaimed Tom, "three spectral wafers, but the colours are different; the red wafer is represented by a *green*, the violet by a *yellow*, and the orange by a *blue*."

"You now then understand what is meant by the spectral or accidental colour of a body;—But let us return to the subject of the Thaumatrope," said Mr. Seymour.

"Behold!" continued he, "the Trojan ships!"

"Ay, ay, sure enough," said the vicar; "but let me see, are their forms according to ancient authority? Very well indeed, Mr. Seymour. Very well; the poops have the bend so accurately described by Ovid and Virgil — '*Puppesque recurvæ*,' as the poet has it. And there is the triton; but is its size in proportion to the vessel? Yes, sir, you are doubtless correct, the figure is generally represented of considerable magnitude on ancient medals; and Silius Italicus, if my memory serves me, alludes to the weight of the image having on some occasions contributed to the wreck of the vessel."

"Spin them round," said Mr. Seymour.

The vicar complied; exclaiming at the same moment, "'*Vos ite solutæ. Ite deæ pelagi.*' They are positively converted into sea-nymphs. '*Mirabile monstrum!*'" cried Mr. Twaddleton.

"Here is another classical device; the representation of Eurydice, as she fell lifeless at the moment Orpheus turned round to gaze on her," said Mr. Seymour.

"Charming! charming! I perceive that it is a copy from the splendid print of Didot in the Paris edition of Virgil."

"Turn it round, vicar."

"See! see! she revives, she opens her eyes, and throws her arms around the neck of her frantic lover: truly, Mr. Seymour, this is a most interesting toy," said Mr. Twaddleton.

Mr. Seymour here observed that he had written an epigram to accompany the subject they had just witnessed, and he trusted that he had given to it a classical *turn*.

"By all means read it; the subject admits of much classical decoration," observed the vicar.

Louisa received the epigram from the hands of her father, and read as follows:—

"By *turning round*, 'tis said, that Orpheus lost his wife;
Let him *turn round* again, and she'll *return* to life."

It could not be expected that Mr. Twaddleton should have admired lines so burdened with puns; but he quietly observed, "I should have preferred a quotation from the fourth Georgic, so beautifully descriptive of the fable."

The next card that was presented for inspection exhibited the metamorphosis of Daphne into a laurel. As the figure revolved, the leaves were seen sprouting from her fingers, and her arms lengthening into branches.

"Come now," said Mr. Seymour, "let us exhibit the figure which has been designed at my request: the change which it will undergo during its revolution may, I trust, on some day be realised; I only regret that it is not in my power to give the vicar so good a *turn*.

"Really, if like Crambe, in Martinus Scriblerus, thou hadst a word for every day in the year, I should certainly say that you were this day under the dominion of the word *turn*."

"You know this resemblance?" said Mr. Seymour, as he showed the figure, painted on one side of the card, to his daughter.

"It is the vicar!" exclaimed Louisa.

It was, indeed, a portrait of that most excellent character, represented in the costume in which he usually appeared.

"Turn it round," said Mrs. Seymour.

"Louisa twirled the cord, and the effect of the rotation was to convert the humble vicar into the dignified bishop; his meagre form was instantly changed into a corpulent figure, which was still farther inflated by the addition of the episcopal robe and lawn sleeves, while his angular features were softened by the graceful curves of an immense wig.

"I will give you a motto for it," said the major, "and may it be prophetic!—RAPID PREFERMENT."

"I will now show you the improvement which has been effected in the construction and use of this toy," said Mr. Seymour. "It consists in altering the axis of rotation while the card is in the act of revolving, in order that the images on its opposite sides may be brought in different positions with respect to each other."

"There cannot be any doubt that such would be the effect, were it possible to change the axis in the way you propose, but how is this to be effected?" asked the vicar.

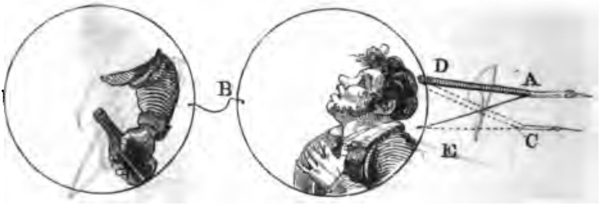
"At first I attempted to produce the change by the addition of several other strings, but I soon found, that, in order to avail myself of this expedient, I should be obliged to stop the card before I could alter the axis, whereas my great object, as I have just stated, was to produce the change while the card was in the act of spinning," answered Mr. Seymour.

"And I shrewdly suspect that such must necessarily be the case, adopt whatever expedient you may," observed the Major.

"No indeed; I have at length succeeded to my entire satisfaction, and that too by a most simple scheme, after having tried without success many very complicated contrivances."

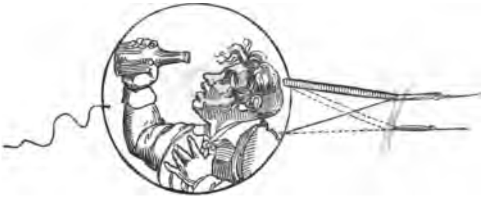
The party were very desirous of witnessing this triumph of skill, and Mr. Seymour produced the card, with its appendages, of which we shall here present our readers with an engraving:—

Fig. i.

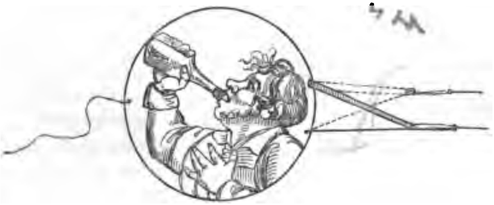


In all respects the card is constructed like the common Thaumatrope; the subject, it will be perceived, is that of a man drinking, the bottle being placed on one side, and the head on the other; upon revolving the card, in the ordinary manner, the two images will appear together as represented in

Fig. 2.



The improvement consists in inserting in one, or, if a still greater change be desired, in both sides of the card, two strings, as seen in Fig. 1; viz. A D and A E, which united at A, form a common string for twirling the card. The cord A D is elastic, while the string A E is incapable of being stretched. If, therefore, while the card is in the act of spinning, the cord A D be pulled with an increased force, it will take the position D C, while the inelastic string A E will at the same time assume that of E C. The consequence of which will be that, instead of the card spinning on an axis in the direction A B, it will now spin on that which is in the direction C B, and we shall accordingly see the images on the opposite sides of the card in different positions with respect to each other; at one moment the bottle will be seen in the hand of the drinker as represented in Fig. 2, and in the next, at his mouth as shown in the cut below:



while, by alternately tightening and relaxing the string, the figure will be seen in the very act of raising and lowering the bottle.

Mr. Seymour having explained the principle of his improvement as we have above related, proceeded to exemplify it by a series of different subjects. We shall select two or three of them for the sake of illustration. A card with a jockey on one side and a horse on the other, on spinning round presented the combined figure; upon tightening the string, in the manner we have described, the card changed its axis, without the slightest halt or hesitation in its rotation, and the rider was in an instant canted over the head of his charger; in a moment, however, he appeared remounted; after which, by pulling the string, with different degrees of force, he was made to stand on the saddle, and to exhibit a number of different movements.

The figure of an Indian juggler was represented in the act of throwing up *two* balls; on spinning the card, and, at the same time, altering the position of the circle, in the manner already described, *three*, and afterwards *four*, became visible. When the card revolved upon its original axis, two of the balls on the reverse side coincided with the two painted on the front, so that during the revolution they fell upon the same spot on the retina, and therefore produced a single impression; but as soon as the position of the card was changed, these spots were brought upon different points, and consequently produced separate and independent images. By alternately tightening and relaxing the strings, the balls were seen in motion, arising from and falling into the hands of the juggler.

The next subject which we shall describe produced a considerable degree of merriment. The vicar inspected the drawing, and observed that he saw a pulpit placed on the banks of a pond; the card was made to spin, when a tailor was seen haranguing from the former, and a goose, at the same instant, fluttering over the water. The circle was ~~now suddenly shifted,~~ and the vicar was desired to state what he saw :—" Why, bless me!" exclaimed Mr. Twaddleton, " the tailor is justly served, he is ducked in the pond, while the goose has taken his place in the pulpit."

Fearing that we may have exhausted the patience of our reader, we shall only relate one more example. It was a Turk, who, by means of the expedient we are illustrating, was made to draw his sabre, and cut off the head of his antagonist, which immediately fell into the hands of the decapitated person, who, like St. Denys, appeared as if walking off with perfect indifference.

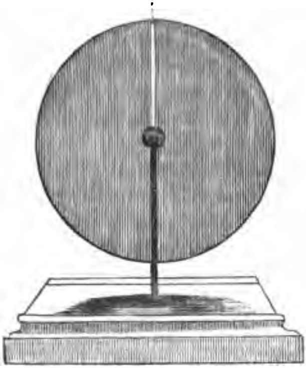
" You must admit that these effects are no less novel than they are extraordinary, and that they are capable of almost endless variation," said Mr. Seymour.

" I admit it all," replied Mr. Twaddleton, " and I have only to express a hope that, amidst all your improvements, you will never lose sight of your first and most laudable design, that of rendering your toy subservient to classical illustration; your triumph will then be complete, and I shall willingly acknowledge that there is not only philosophy but literature in your sport."

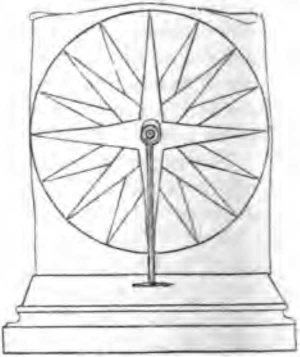
" I must not quit this subject," said Mr. Seymour, " until I have exhibited another toy which, like the Thaumatrope, is indebted for its effect to the optical principle, which I trust is now well understood by all present, viz. that *an impression made on the retina lasts for a certain period after the object itself has been withdrawn.*"

The annexed wood-cut represents the instrument to which Mr. Seymour alluded.

A



B



It consists of a disc of blackened tin plate, which is made to revolve on its axis in the manner above exhibited. A narrow opening extends from the circumference to the centre as seen at A. If a device of any kind, as a star (which for increasing the beauty of the experiment ought to be transparent, and illuminated with a lamp) be placed behind the disc, it is evident that, as long as the circle remains at rest, no other part of the figure can be visible than that which is immediately behind the slit A, but the instant it is put into rapid motion, the whole of the star will be seen, as exhibited in figure B.

Mr. Seymour observed that the explanation of the phenomenon was obvious;—each successive portion of the figure seen through the opening remains on the eye, until the circle has completed its entire revolution.

"This experiment," continued Mr. Seymour, "admits of a very curious modification, which I shall now proceed to exhibit."

Three coloured wafers were then placed, at equal distances from each other, on the disc, and the instrument having been arranged before a looking-glass, the party were desired to observe the reflected image as the circle revolved.

"The wafers are blended into one continuous zone," observed Mrs. Seymour.

"To be sure," said Louisa, "upon the same principle that the ignited stick appears as a fiery circle."

"It would be very strange, after the different experiments we have seen, if we were not able to explain the present appearance," observed Tom.

"The fiery circle produced by the revolving stick is a much better illustration of the principle; I do not see what object Mr. Seymour has in thus multiplying his experiments," said the vicar.

"Gently, if you please, Mr. Twaddleton, and, before you favour us with your criticism, wait until I have concluded my experiment. You have seen that the reflected image of the revolving wafers appears as a continuous zone, and you have very correctly explained the reason of such an appearance; but I must now request you to inspect the reflected image through the slit in the disc, as it revolves, and say what new effect you observe."

"How very strange!" exclaimed Tom; "I see the three wafers very distinctly, and perfectly at rest."

"Impossible," exclaimed the vicar—"let me have a peep. Why, I declare, they appear, as you say, stationary, although I know them to be in rapid motion; as sure as fate I shall become a Cartesian."

The Major, Louisa, and Mrs. Seymour, were all equally surprised, and incapable of giving any explanation of the phenomenon they had witnessed.

"Let us remember," said Mr. Seymour, "that in viewing the image through the slit in the revolving disc, we catch but a momentary glance as it passes before the eye, and that the image thus produced on the retina is retained until the next revolution again brings the slit into the same position. Now it is evident, that before the eye can ascertain a body to be in motion, it must observe it in two successive portions of time, in order to compare its change of place; but in the experiment under consideration, the glance is momentary, the wafer is no sooner seen than it passes away; its figure alone is impressed upon the retina, and this impression is continued without any change, until the circle completes its round, and consequently the image must appear at rest."

"I understand you; the figure, but not the motion, of the wafer is discernible in the short period during which it is visible through the slit," observed the vicar.

"It was my intention to have carried this subject still farther, and to have exhibited some very extraordinary optical illusions produced by the revolution of wheels in different directions, and at different velocities, for a knowledge of which we are indebted to Mr. Faraday;* and in mentioning the name of that distinguised philosopher," said Mr. Seymour, addressing himself more particularly to the vicar, "I cannot help remarking, had any proof been wanting to show that '*Philosophy in Sport may be made Science in Earnest,*' the juvenile leçtures of that gentleman at the Royal Institution would have afforded it."

"True," said Mrs. Seymour, "and they have moreover shown that philosophical recreations, and the most abstruse researches, are not incompatible with each other—that, under the guidance of a master-mind, science may be conducted from her almost inaccessible heights and placed within the reach of all who are anxious to court her."

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* See Journal of the Royal Institution, No. 2.

The party now dispersed, not less gratified than they had been instructed by the lesson of the morning.

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The mighty magician of the North has compared the course of a narrative to the progress of a stone rolled down hill by an idle truant boy, "which at first moveth slowly, avoiding by inflection every obstacle of the least importance; but when it has attained its full impulse, and draws near the conclusion of its career, it smokes and thunders down, making a rood at every spring, clearing hedge and ditch like a Yorkshire huntsman, and becoming most furiously rapid in its course when it is nearest to being consigned to rest for ever: even such," says he, "is the course of a narrative, the earlier events are studiously dwelt upon; but when the story draws near its close, we hurry over the circumstances, however important, which your imagination must have forestalled, and leave you to suppose those things which it would be abusing your patience to relate at length."

Let the reader of the present work accept this explanation, as an apology for the abrupt and rapid manner in which we shall now accelerate our narrative. Since the last lecture, our history has advanced nearly three weeks, during which interval, the Major had made every arrangement for the approaching marriage. It was finally agreed that the ceremony should be performed at Overton church; and as the "happy couple" expressed a wish to pass their "honey moon" in a retired part of Yorkshire, the Major consented to postpone his fête until after their return; nor was he displeased at such an arrangement, as it afforded time for getting up his entertainment on a more liberal scale than could otherwise have been accomplished. We shall now avail ourselves of that peculiar Lethean property which has been often ascribed to the pen of the author, and commit the reader to the arms of Morpheus, where it is our intention that he shall remain until the morning of the nuptials.

* * * * * *
* * * * * *

Reader, awake! the sun has risen, and Nature is robing herself in her most gorgeous apparel for the approaching ceremony; the family of the lodge have been already roused from their slumbers by the attendance of minstrels, whom the vicar had directed to salute the bridal party at break of day. ——But hark! while we are thus trifling, the village of Overton is in a bustle; the marriage ceremony is over; the bells of the church are ringing right merrily their festive peals; many a handkerchief is waving from the cottage windows, while the doors are decorated with garlands; the vicarage is ornamented with fragments of Venetian tapestry; the peasants, dressed in their holiday garments, are carrying nosegays in their hands, to present to the bride as an offering of their respect, or to strew in her path, as an emblematic expression of their wishes.

The party having reached Osterley Park, we were proceeding to describe the banquet which had been prepared, and the various devices and emblems with which it had been decorated, under the classical direction of the vicar, when alas! our publishers, like the harpies of old, unexpectedly pounced upon us, and warned us from the feast—"*diripiuntque dapes.*"

"You have already exceeded the prescribed limits—you must close the scene—remember that you have engaged to condense the work into one volume," said they. We remonstrate, but in vain. We request but a few pages, in order that we may give our characters a dramatic exit; but they reply to us in the words of Sneer, in the Critic, " O never mind! so as you get them off the stage, I'll answer for it the *reader* won't care how."

You see then, gentle reader, how vain it would be to struggle against such arbitrary and tasteless masters; we shall, therefore, without any farther apology, ring the manager's bell, and drop the curtain.

# CHAPTER XVIII.

PREPARATIONS FOR THE APPROACHING FETE.—THE PROCESSION OF THE BRIDAL PARTY TO OSTERLEY PARK.—THE MAJOR AND HIS VISITORS SUPERINTEND THE ARRANGEMENTS IN THE MEADOW.—THE CURIOUS DISCUSSIONS WHICH TOOK PLACE ON THAT OCCASION.—THE ORIGIN OF THE SWING.—MERRY ANDREWS.—TRAJETOURS, &C.—THE DINNER AT THE HALL.—THE LEARNED CONTROVERSY WHICH WAS MAINTAINED WITH RESPECT TO THE GAME OF CHESS.

A MONTH had nearly elapsed since the bridal pair had quitted Overton; and during this period, the greatest activity had been displayed by the itinerant corps of Momus, under the superintendence of their manager, Ned Hopkins. The various show-booths had been erected by their respective owners with an expedition that might have put many a prouder architect to shame; the marquees and temporary rooms had been completed under the management of Tom Plank; and for those, whose appetite might hold precedence of the senses of sight and hearing, ample funds of gratification had been provided by the accomplished hostess of the "Bag of Nails," whose grim troop of kettles and stew-pans had, during the whole of the week, been chirping and chuckling over the kitchen range, the very cheeks of which had cracked from yawning. The Major now anxiously awaited the arrival of every post, in expectation of a letter that might announce the day upon which Henry Beacham and his bride would return to Osterley Park. At length the long anticipated intelligence was received, that they might be expected at Overton by four o'clock on the day after the morrow. The vicar was immediately summoned to a council, and on his arrival, retired with the Major for the purpose of consulting the chronicles of Holinshed and Froissart, touching certain points of ceremonial that might guide them in their arrangements for receiving the bride. The vicar pleaded in favour of the forms that were observed on the occasion of the public entrance of Queen Isabella into the city of Paris, but the major objected to the plan, on account of the pageant representing the siege of Troy, a point upon which the vicar most pertinaciously insisted; so that the gentlemen separated without having arrived at any satisfactory conclusion upon the subject, and the question was transferred to another jurisdiction. No sooner had it become known that Mr. and Mrs. Beacham were shortly to arrive, than the more respectable yeomen of the parish assembled at the village inn, to concert a plan for receiving them with all due honour, when it was finally arranged, that the village should be decorated with garlands, and the May-pole erected on the spot, where its gaudy streamers had for so many ages annually floated on the breeze of spring. It was farther resolved, that every person who could furnish himself with a horse, should attend at a certain spot by the hour of three, in order to advance in procession, and escort the happy couple through Overton to Osterley Park. The major, upon receiving the communication of these resolutions, issued such orders as might be necessary for carrying them into effect; he also signified his desire, that those musicians who had lately arrived for the impending festivities should be in attendance at the place and hour that had been fixed upon. The friends of Major Snapwell had already arrived at the Park; and Overton Lodge was overflowing with visitors. Tom had also joined his family circle.

At three o'clock on the appointed day, twenty signal guns were discharged from the Park—the village bells struck up a festive peal—the flag was hoisted on the spire of the church; and upwards of forty respectable yeomen, farmers, and tenants, mounted on their horses and decorated with ribands and flowers, had assembled as an escort.

The church clock chimed the quarter past three, as the carriages of Major Snapwell and Mr. Seymour, and those of their guests, drawn by highly decorated horses, entered the village; the peasants immediately drew back, so as to form an avenue through which the party might pass, while shouts of gladness rent the air. Each horseman had provided a large bough of oak or elm, so that the cavalcade in motion appeared like a moving grove, and reminded Mrs. Seymour of the advance of "Birnam Wood to Dunsinane." The carriages, preceded by a band of music, occupied the van of the procession; then came about fifty village maidens, each carrying in her hand a basket of flowers; next followed the horsemen; and the procession was closed by a dense group of peasants, who had come from all the country round. The vicar appeared on horseback, bustling in all directions, now conversing with the major, now with Mr. Seymour; at one time moderating the pace of the horsemen, and at another, keeping back the pedestrians, whose eagerness to push forward created an inconvenient crowd in the foremost ranks. Mr. Twaddleton held in his right hand a wand decorated with ivy leaves, and which resembled in appearance the thyrsus of Bacchus, except that the cone on its summit had been replaced by a bunch of roses. This was a classical conceit; and he fully explained to the major the reason of his having adopted such a device for his wand of office.

"The rose," said he, "was dedicated by Cupid to Harpocrates, the god of silence, to engage him to conceal the secrets of Venus; hence has this flower ever since been considered as the symbol of silence; for which reason it was customary to hang a rose over the banqueting-table, to signify that what was there spoken should be kept private, or 'under the rose;' whence, also, to present, or hold up, this flower to any person in discourse served, instead of an admonition, to intimate that it was time for such person to hold his peace. In like manner," continued the antiquary, "you will observe that, by virtue of my wand, I shall impress the obligation of silence upon the crowd, and easily calm any undue clamour that may arise."

The cavalcade had advanced little more than half a mile, when the major suggested the propriety of halting, until his nephew and niece should arrive; to this proposition the vicar readily acceded, and accordingly issued the necessary orders.

They had not, however, remained stationary above five minutes, when a carriage and four was seen at the brow of the hill, advancing in full speed. A general and simultaneous shout burst from the crowd; upon which the vicar raised his wand, and all was hushed. How far such an effect might be attributed to the influence of his wand, we shall leave the sagacious reader to determine; but the party smiled at so striking an instance of classical credulity; and Mr. Twaddleton, highly gratified by his triumph, rode forward to the chariot, which was not more than two hundred yards distant. It contained Mr. and Mrs. Beacham, whom the vicar no sooner perceived than he again raised his wand, and again witnessed the influence of its spell. The chariot instantly stopped, and, in the next moment, Mr. Twaddleton was seen in earnest conversation with the travellers. He informed them that the group they saw was a cavalcade of villagers, who had been awaiting their arrival on the road, in order to escort them in rural triumph to Osterley Park. He then presented

Mr. Beacham with a bag of nuts, "that the bridegroom," as he said, "might be enabled to comply with the ancient Roman custom* of throwing nuts amongst the boys to be scrambled for;—*sparge, marite, nuces*, as Virgil has it;—*da nuces pueris*, as Catullus sings." Mr. Beacham held the vicar in too much respect to laugh at his eccentricities, and he therefore accepted the bag, with a determination to gratify his wishes in so harmless a whim.

Jerry Styles was now directed to forward the two messengers to Osterley Park; and he accordingly opened a basket, from which flew two carrier pigeons, who immediately soared into the air, and having attained their greatest altitude, and remained apparently stationary for a few seconds, darted off in the direction of Osterley Park; every eye was steadfastly fixed upon the birds; and a murmur of satisfaction and wonder ran through the ranks, as the sagacious animals lessened in the distance. (45)

The musicians now struck up a grand march;—the whole cavalcade was in motion. Mr. Beacham's chariot having been drawn on one side of the road, the carriages and horsemen proceeded to take their stations in the rear; the company in the former kissing their hands, and waving their handkerchiefs, while the latter lowered their branches, and cheered, as they passed.

The damsels, in advance of Mr. Beacham's carriage, opened their baskets, and strewed the road with flowers as they moved forward.

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* Many reasons have been assigned for this custom; the more commonly received opinion is, that it was intended as a token of the bridegroom having left off childish diversions, and entered on a more serious state of life; whence *nucibus relictis*, has passed into a proverb. This conjecture is favoured by Catullus:—

"Satis diu
Lusisti nucibus. Lubet
Jam servire Thalassio.

We have already stated that *nuces* were played with like our marbles; the custom, therefore, might be intended to express that the bridegroom had deserted his play-things.

"Hark!" exclaimed the major: "the pigeons have arrived at the Park, and my orders have been faithfully obeyed: they are firing a salute."

"And it has been heard at the village," said the vicar; "for the bells have just commenced their peal of welcome." But we are exhausting the patience of our readers with the details of a ceremony, in which it is very probable they may feel but little interest; although we freely confess that, to ourselves, few pageants have such attractive charms as those innocent and simple manifestations of genuine feeling which are to be met with in rural life, where the heart has not yet been chilled by that benumbing influence of what has been termed "the progress of civilisation;" and which has exchanged the free and warm impulses of our nature for cold and studied forms, or for an artful display of factitious sentiment.

During the progress of the procession through the village, Mr. Beacham had not been unmindful of the vicar's request: he poured a shower of nuts amongst the boys, which occasioned much frolic, and good-humoured contention; while the peasants caught and cracked them, without any suspicion of the Roman custom they were assisting to perpetuate.

Having arrived at Osterley Park, the horsemen formed a double line, through which the several carriages passed. The gates were then closed; and the vicar, stepping forward, thus addressed the assembled multitude:—

"Well-beloved friends and parishioners, I am desired by Major Snapwell to inform you that refreshments have been prepared in the village, of which you may all partake on your return. Your admission into the Park this evening would interfere with those arrangements which are in progress for to-morrow's jubilee: let me, therefore, request that you will all retire peaceably."

In compliance with this intimation, the whole assembly, after having given three hearty cheers, retired to the village, where several barrels of beer had been disposed in readiness for the libation.

The vicar, after he had completed his harangue, rejoined the party at the Park, where its hospitable owner had prepared a sumptuous dinner. It was, however, proposed that the vicar, with the major, and such of his guests as wished to inspect the preparations, should previously walk round the grounds. Tom and his sisters begged that they might be included in the party; a request which their father readily granted, as he said that some opportunity might occur for explaining the nature of those exhibitions which they were to witness on the following day. The same feeling induced Mr. and Mrs. Beacham and several other visitors to join the party, hoping that they also might profit from the discourse which Mr. Seymour intended to hold for the instruction of his children. The reader will probably be induced, for similar reasons, to accompany them. If he has attentively read the preceding pages of this work, we hope he has become convinced that the lessons of youth may occasionally convey instruction as well as amusement to those of riper years.

Ned Hopkins having been summoned to attend the party, and receive the final orders of the vicar, they proceeded to the elm-meadow, where the grand fair was to be held, and in which were disposed a long line of booths for the motley exhibitions to which they were dedicated.

"What have we here?" exclaimed the major, as he entered the meadow; "a row of poles!"

"Ned Hopkins," cried the vicar, "how has it happened that the ropes have not been affixed to these poles? Have I not said that every arrangement must be completed this evening? Those poles," continued the vicar, addressing himself to Major Snapwell, "are intended for swings, from which the younger peasants will, doubtless, derive much amusement, while their sires are engaged, in the adjoining field, by the more manly exercises of quoits, foot-racing, wrestling, hurling, &c. You are, of course, aware, gentlemen, that in admitting the swing amongst the pastimes of the day, I have the support of classical authority: its origin may be traced to the Icarian games, the celebration of which consisted in persons balancing themselves on cords, attached to two trees; or, in other words, in swinging. They were instituted in commemoration of the death of Erigone, who no sooner discovered the murder of her father Icarus, than she piously hung herself at his tomb."

"It is certainly very curious," said the major, "to observe how frequently a popular ceremony or custom has survived the tradition of its origin; it is thus, for instance, that the fond mother still suspends the coral toy around the neck of her infant, without being in the least aware of the superstitious belief from which the custom sprang (46); and I have little doubt but that we shall to-morrow hear the chorus of 'Derry-down' re-echoed by those who probably never heard of the Druids, and much less of the choral hymns with which their groves resounded, at the time of gathering the misletoe. But let us proceed; for what has yonder stage been erected?"

"That is the *hoistings*, sir," exclaimed Ned Hopkins, "from which Giles Gingerly, the celebrated American merry-andrew, will exhibit his buffoonery, and vend his nostrums."

"Hoistings! why, Ned, you pronounce the word as though your mouth were filled with hot pudding," said the major.

"I ask your pardon, sir," replied Ned; "but my father would never suffer me to pronounce it in any other manner; for he always maintained that *hustings* was a corruption for *hoistings*, it being a stage upon which the actor is *hoisted* or elevated above the surrounding crowd."

"I believe he is right," muttered the vicar.

"Papa," said Tom, "pray tell me what is a merry-andrew."

"Ask the vicar," replied his father.

"The mountebank, who united the professions of joculator and physician, was of ancient date, and during the two last centuries has figured away with considerable success. He usually appears on a temporary stage, and prefaces the vending of his nostrums with a pompous harangue; and, the better to attract the notice of the gaping spectators, he displays some of the performances practised by the jugglers, while his inseparable companion, the *bourdour*, exhibits numerous tricks, and puts the populace in good humour by wit and raillery. The medical fraternity, known in England by the name of *Merry-andrews*, and who are the companions of the mountebank, derived their foundation from Dr. Andrew Boorde, who lived in the reigns of Henry VIII. Edward VI. and Queen Mary, and was constantly in the habit of frequenting fairs and markets, at which he harangued the populace: his speeches were extremely humorous, and occasioned considerable mirth; but, notwithstanding the infallibility of his nostrums, like Paracelsus, he died with a bottle of his elixir in his pocket. His successors in the same line naturally endeavoured to emulate the humour of their master, and hence this whole class of vagabond tinkers of flesh and bone acquired the generic appellation of '*Merry-andrews*.'"

"And pray what are *nostrums?*" asked Louisa

"'*Nostrum*,' my dear, signifies *our own*, and is applied to any medicine which is prepared by a secret process, and sold for the private advantage of an individual; but, since secrecy is never used on such occasions except as a cloak for imposture, the word very generally conveys an expression of ridicule or contempt."

The company proceeded in their inspection.

"What have we there, Ned Hopkins?" said Mr. Seymour, as he pointed to a booth of larger dimensions than those which surrounded it.

"In that booth, 'the Emperor of all the Conjurors' will perform his wonderful art of 'sleight-of-hand,'" replied Ned.

"A lineal descendant of the *Tragetour* of the fourteenth century," observed the vicar; "a class of artists who, with the assistance of dexterity of execution, and various kinds of machinery, deceived the eyes of the spectators, and produced such illusions as were usually supposed to be the effect of enchantment; on which account, they were frequently ranked with magicians, sorcerers, and witches. They were greatly encouraged in the middle ages, and travelled in large companies, carrying with them such machinery as was necessary for the performance of their deceptions."

"And what may be the etymology of *tragetour*?" asked Mr. Seymour.

"A late ingenious writer supposes it to be derived from *trebuchet*, or *trap-door*, of which he made frequent use during his performance."

The company passed to the next booth.

"There," said Ned, "will be exhibited vaulting, tumbling, jumping through hoops, balancing, grotesque dances by the clown, and dancing upon the tight-rope."

"The tragetour rarely executed this part of the performance himself," said the vicar, "but left it to some of his confederates."

"And yet I should have thought it the most profitable department of the art," observed the major; "for it was so patronised as to secure the reception of its professors into the houses of the nobility. In the reign of Edward II. a tumbler rode before the king, and so delighted his Majesty, that he rewarded him with a gratuity of twenty shillings, a very considerable sum in those days."

The whole party, having expressed their satisfaction at the genius which Ned Hopkins had displayed in selecting and arranging the various kinds of amusement, were conducted by the vicar to a small enclosure, at a short distance from the fair, which he had appropriated to the youths of the village, who had been trained to perform the "*Ludus Trojæ*," according to the description left us by Virgil in the fifth Æneid.

"I shall be curious to witness the sport," said the major, "for Lazius asserts, in his commentaries upon the Roman Republic, that the jousts and tournaments, so much in fashion about two or three hundred years ago, were indebted for their origin to this game; and that '*Tournamenta*' is but a corruption of '*Trojamenta*.'"

"Undoubtedly," replied the vicar; "and the learned and noble Du Fresne entertains the same opinion: by some the word has been derived from the French *tourner*, to turn round with agility; yet the exercises have so much resemblance, as to prove the one an imitation of the other."

"Come, come, my good friend," exclaimed the honest major, "all these preparations are highly laudable, and will, no doubt, afford satisfaction to the spectators, for whose amusement they have been designed; but there are other senses, besides the eye and ear, to be gratified upon this occasion. I have not yet observed any arrangements for the dinner."

"Fear not, major; the awning which has been erected for that purpose is within sight; observe you not the banners which are floating yonder?" said the vicar.

"Ay, ay, to be sure I do; and let me tell you, that you have taken up a very snug position."

Tables had been arranged, under an awning of canvass, in the form of a cross, and were capable of accommodating about two hundred persons. On a platform, somewhat elevated, was another table appropriated to the major and his guests, on which covers were laid for forty.

"You perceive, major," said Mr. Twaddleton, as they approached the scene of future action, "that the fare which has been provided is simple but substantial, and I trust will be considered as no less according with English hospitality, than with classical propriety."

"The beef certainly predominates," said the major, "and I observe that most of the joints are roasted."

"Quite correct, sir; the ox is the animal most frequently spoken of, as furnishing food for ancient heroes; and you will remember that Homer rarely mentions any other than *roasted* meat."

"I perceive that you have been more miscellaneous in your arrangement of the upper table."

"I have placed before you a chine of beef, because Menelaus set that dish before Telemachus at the marriage-feast of his son."

"I wish to know what seats are to be appropriated to my young friends the little Seymours?" said the major.

"I regret, extremely do I regret, to say, that they cannot with propriety join our party," replied the vicar, gravely.

"Not join the party! zounds, sir, but I insist upon it;—not join the party!"—

"Be calm, major; and believe me that I shall feel the privation as keenly as yourself; but would you countenance a measure, which is decidedly in opposition to every classical authority? Never, as Suetonius has expressly declared, did the young Cæsars, Caius and Lucius, eat at the table of Augustus, until they had assumed the *toga virilis.*"

"A fig for Suetonius; he is not to be trusted; has it not been said that while he exposed the deformities of the Cæsars, he wrote with all the licentiousness and extravagance with which they lived? Besides, can we trust the opinion of a man, on a subject of etiquette, who was banished from the court for want of attention and respect to the Empress Sabina? You must produce some better authority, my dear Mr. Twaddleton; search the Grecian writers; depend upon it that some direct or implied sanction to the plan is to be discovered; the oracles of old may generally be so interpreted as to meet the wishes of the translator."

"Gently, Major Snapwell; speak not so irreverently of the luminaries of antiquity; nor expect me to distort passages from their original and intended significations. An idea, however, has just struck me, which may, possibly, be turned to your advantage; and yet there are many difficulties; for it cannot be said that this feast has been conducted with the utmost frugality; and, therefore, must not be compared with the Lacedemonian '*Syssitia,*' or public entertainments, whither the youths were obliged, by the lawgiver, to repair as to schools of temperance and sobriety, and where, by the example and discourse of the elder men, they were trained to good manners and useful knowledge."

"A case exactly in point," exclaimed the major. "Must not the classical character of our entertainment convey instruction? I vow it runs parallel in every particular with the Syssitia of Lacedemon; and I therefore affirm, that it would be illegal, according to the law of Lycurgus, to prevent the presence of the young Seymours."

"Your argument has colour, major; I must admit that Mr. Seymour's lessons are too valuable to be lost; well, I consent; it shall be a Lacedemonian entertainment, and my young friends shall be accordingly accommodated with seats."

On their return from the banqueting-tables, the party inspected the preparations for the fire-works, and the ships constructed for the naumachia; we shall, however, at present decline offering any description, as we prefer explaining them in operation.

The reader will now be pleased to imagine that the party having returned to the mansion, had partaken of the hospitable repast which the major had provided for them; he may farther suppose that tea had been served up, and the amusements of the evening commenced; for it is at this exact moment that the course of our narrative is resumed. Mrs. Beacham was delighting the assembly by a splendid display of her musical talents; the major and Mr. Seymour were engaged in a game of chess.

"There you sit, gentlemen," exclaimed the vicar, "so absorbed in your game, as to have remained quite insensible to the sweet sounds with which Mrs. Beacham has been charming us; but you stand excused, for Seneca admits the fascinating power of the '*ludus latrunculorum,*' or game of chess. You no doubt remember the story that he tells us of one Canius Julius, who, having been sentenced to death by Caligula, was found by the centurion, when he came to conduct him to execution, so interested in a game of the '*latrunculi,*' as at first to be insensible to the summons, and that he did not prepare to depart until he had counted his men, and desired the centurion to bear witness to his having one more piece on the board than his adversary, so that the latter might not boast of a victory after his death."

"Indeed!" said the major; "but unfortunately for your story, the ancients were not acquainted with the game of chess."

"What absurd proposition am I next to expect?" cried Mr. Twaddleton. "You surely cannot have read the poem to Piso, which some will have to be Ovid's, others Lucian's: but no matter; it is an ancient poem, and accurately describes the game of '*latrunculi*.' I myself believe, from a particular line in Sophocles, that chess was invented by Palamedes, at the siege of Troy; although Seneca attributes it to Chilon, one of the seven Grecian sages. My friend Mr. Seymour, who is, upon all occasions, desirous of imparting wisdom through the medium of games, and of 'turning sport into science,' will no doubt agree with those who fancy that it was contrived by Pyrrhus, king of Epirus, as a method of instructing his soldiers in the military art; and I must admit that the game expresses the chance and order of war so very happily, that no place can lay so just a claim to its invention as the camp: '*ludimus effigiem belli*,'* as Vida says."

"Check to your king!" cried the major; "while you are considering of the best way to get his majesty out of the scrape, I will endeavour to extricate the vicar out of the quagmire in which he is floundering. My dear Mr. Twaddleton," continued the major, "you speak as if it were an admitted fact that the '*ludus latrunculorum*' was synonymous with our chess. I admit that it was a game played with *Tesseræ* or squares, and *Calculi* or pieces; but it does not follow that it must have been chess; indeed, the learned Dr. Hyde, whose researches into Oriental games are as much distinguished for accurate discrimination as for profound scholarship, considers it to have resembled our *draughts*.*

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* "War's harmless shape we sing, and boxen trains
Of youth, encount'ring on the *cedar* plains.
How two tall kings, by different armour known,
Traverse the field, and combat for renown."

"You are to move, major," said Mr. Seymour.

"Then I shall take your castle, and open a fresh battery upon the vicar," replied Major Snapwell.

"So you may," cried Mr. Twaddleton, "but you will not easily drive me from my position; supported as I am by Vossius and Salmasius, and an army of valiant combatants."

"The learned Hyde has endeavoured to prove that chess was first invented in India, and passed from thence to Persia and Arabia. Fabricius considered it a Persian game, and I must say that I am inclined to coincide with him. The terms in present use may evidently be traced to an Oriental source. *Schach*, in the Persian language, signifies king, and *schachmat*, whence our *check-mate*, the king is dead, the original words having been transformed by progressive changes; thus we have *schach*, *echecs*, *chess*; and by a whimsical concurrence of circumstances, have arisen the English words *check*, and *exchequer*."

"I take your *queen*," cried Mr. Seymour.

"Ay; and I take a *bishop* in return," said the major.

"Well," observed the vicar, "if an Oriental nation really gave origin to the game, it could not, at all events, have been China; since the policy of that people is to exclude females from every kind and degree of influence and power, whereas the *queen* at chess is a powerful and important piece."

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* 'Ludus Latrunculorum;' ludus, anglice dicitur *Draughts*, à trahendo calculos.—Hyde *de Ludis Orientalium*. Oxon 1694.

"You must not lay too much stress upon the names of the several pieces," observed the major, "since they have varied in different ages and countries. The castle is sometimes called the *rook*, from the Italian word *rocca*, which signifies a fortress placed on a rock: the piece which we call the *Bishop* has been termed by English writers *alphan*, *aufin*, &c. from an Arabic word, signifying an elephant; sometimes it was named an *archer*; by the Germans, the *hound* or *runner*; by Russians and Swedes, the *elephant*; by Poles, the *priest*; and by the French, at a very early period, the *fou* or *fool*; the reason of this last appellation seems to be, that as this piece stands on the sides of the king and queen, some wag of the times styled it the *fool*, because anciently royal personages were commonly thus attended, from want of other means of amusing themselves."

"You cannot thus account for our term *bishop*," observed Mr. Seymour, "as our kings and queens have never had such attendants."

"Nor is it very easy to ascertain the period at which it was introduced," replied the major; "in Caxton's time it was styled the *elphyn*. I should think it probable that the change of name took place after the Reformation."

"It is probable that the pieces not only underwent changes in name, but changes in value or power," observed Mr. Seymour, "as the game descended through different ages and countries."

Mrs. Beacham, who had been for some time listening with much interest to the curious discourse we have just related, here ventured to ask a question.

"As you appear to have taken some trouble to ascertain the origin of this game, you can perhaps inform me at what period it was introduced into England."

The major replied, that the learned Hyde supposed it to have been first known in our country about the time of the Conquest; but that Mr. Barrington believed it to have been introduced during the thirteenth century, upon the return of Edward I. from the Holy Land, where he continued so long, and was attended by so many English.

"It is certain that our ancestors played much at chess before the general introduction of cards," observed the vicar, "as no fewer than twenty-six English families have emblazoned chess-boards and chess-rooks in their arms, and it must therefore have been considered a valuable accomplishment."

"Cards," observed the major, "must have been known in England previous to the time of Edward IV.; since a statute was passed in that reign against their importation; but they did not become general for many years, and the progress of the custom appears to have been extremely slow."

"Check, — and mate!" exclaimed Mr. Seymour.

"Upon my word, I have lost the game. Mr. Twaddleton, I lay this to your account," said the major; "you ought not, sir, to have intruded your antiquarian discussions at such a time."

"You have lost the game, major, because, like Charles XII. of Sweden,* you are too fond of advancing your king; but it is quite natural that you should feel mortified by your defeat: a person never likes to be beat at chess, because it is a trial of skill and address; chance has no place, and no one, therefore, loses except in consequence of the superiority of his adversary. You may remember that William the Conqueror, upon being *checkmated* by the Prince of France, knocked the chess-board about his pate, an event which became the source of much future enmity. I must say," continued the vicar, "that this, in my view of the matter, is an imperfection in the game; for, if it be the type or representative of a military campaign, fortune should have some share in deciding the fate of the day; and, if I remember correctly, Sir William Jones has stated that the use of dice, to regulate the moves, was formerly introduced in the East."

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* Voltaire tells us that Charles XII. always lost the game at chess, from his eagerness to move his king, and to make greater use of him than of any of the other pieces.

"I will give the major his revenge whenever he pleases," said Mr. Seymour; "but as I well know how dearly the vicar loves an antiquarian anecdote, if he will listen I will furnish him with one that will be probably new to him. Do you observe the form of the chess-board, resembling, as you perceive, two folio volumes?" said Mr. Seymour. "The origin of it was this: Endes, bishop of Sully, forbade his clergy to play at chess. As they were resolved, however, not to obey the command, and yet did not dare to have a chess-board seen in their houses or cloisters, they had them bound and lettered as books, and called them their wooden gospels. These same monks had also drinking vessels bound to resemble the breviary, and were found drinking when it was supposed they were at prayers."

## CHAPTER XIX.

THE ARRIVAL OF THE POPULACE AT OSTERLEY PARK.—THE COMMENCEMENT OF THE FESTIVITIES.—DANCING ON THE TIGHT AND SLACK ROPE.—BALANCING.—CONJURING.—OPTICAL ILLUSIONS.—VARIOUS GAMES.—THE PENTHALUM.—THE BANQUET.—GRAND DISPLAY OF FIREWORKS.—CONCLUSION.

Never had the rosy fingers of Aurora shown so much reluctance in unbarring the gates of the East, as on the morning of the Osterley Jubilee; at least, so thought about half a score peasants, who, fevered by anxiety and expectation, had arisen from their beds long before the break of day.

At length, however, the sun arose; but indignant no doubt at the accusations he had so unjustly suffered, he immediately veiled his fiery countenance in dark and lowering clouds: here, then, was a fresh source of doubt and anxiety; would the day be rainy? The gardener at Overton Lodge was immediately sought and consulted; and, cheering as were his predictions, they scarcely succeeded in dispelling the gloom which shaded many a fair countenance. The apprehension of disappointment was, however, suddenly relieved; for between nine and ten o'clock the sun re-appeared, beaming in all his glory, and shedding the brightest refulgence on the scene of the approaching festivities. At this period hundreds of villagers, dressed in their holyday attire, were seen pouring along the high road, or winding their way through the verdant valleys. So admirable had been the arrangements for the admission of the populace into the park, that great as was the concourse of spectators, not the slightest impediment occurred during their entrance.

At half-past ten o'clock the whole population of the country had assembled; the various performers were on their respective stages; and the arrival of Major Snapwell and his guests was eagerly expected, as a signal for the commencement of the festivities of the day.

At length a distant murmur was heard in the direction of the house, which gradually increased as it approached the meadow; until it swelled into one grand and universal chorus. The vicar appeared with his wand of office, which he no sooner waved in the air than the murmur gradually subsided. Major Snapwell and his friends, Harry Beacham and his bride, and the Seymours with their children, followed. The several bands, stationed on the platforms erected before the show-booths, simultaneously struck up the national anthem of God save the King, in which the whole multitude joined, and produced one of the most surprising and thrilling effects ever witnessed.

There were eight booths appropriated to the exhibitions; and it had been arranged that each should commence at the same time, and repeat its performances eight times during the day; so that by dividing the spectators into eight groups, and delivering to each person a ticket distinguished by a particular number, every spectator at once knew the booth into which he was to enter; and having witnessed the exhibition, he was directed to exchange his ticket; by which means every chance of confusion was avoided, and each person was enabled to witness, successively, every performance.

The vicar and the party entered the first booth, and were followed by all those whose ticket was distinguished by No. 1.; those of No. 2. at the same time entered the second booth, and so on.

The first show was appropriated to the various exhibitions of vaulting, tumbling, balancing, and rope-dancing. During the performances of the balancer, Tom Seymour's attention was riveted on the artist; he watched every movement, and examined its effect in preserving the centre of gravity within the base. "Papa," cried the delighted boy, "I never experienced so much interest in a performance of this kind, until I was capable of explaining the principles upon which it was conducted. I have attentively followed every change of position, and discovered the effect of such changes upon the line of direction."* As to the *wire-dancing*, Tom observed that he saw very plainly the swinging of the wire backwards and forwards diminished the difficulty, and assisted the actor in keeping his equipoise.

Mr. Seymour was highly delighted with these remarks; and, casting an intelligible look at Mr. Twaddleton, who was seated near him, he exclaimed, "Well, vicar, you will surely now admit that the pleasures which arise from sport are heightened by the admixture of science."

"My dear Mr. Seymour," replied the vicar, "you well know that I have long since become a convert to your principles; I confess, however, had that not been the case, the expressions of satisfaction and delight which have just fallen from my little playmate, Tom, would have removed all my prejudices."

"See, see!" exclaimed Louisa, "how very extraordinary! I declare that the plate, sword, key, and tobacco-pipe, are all balanced as they revolve on the chin of the performer."

"And do not you know, Louisa," replied Tom,

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* See p. 75.

" that the revolution of the plate and sword, which appears to render the execution so much more astonishing, actually diminishes the difficulty of the performance?"*

Thus did Tom Seymour continue to point out successively the philosophical principles upon which each of the tricks might be supposed to depend.

The next booth into which our party entered was that of Crank Smirky, the celebrated conjuror, who invited the company to witness his wonderful display of the art of legerdemain; he was dressed as an astrologer, with a loose gown of green velvet, and a red cap; he had a long grey beard, and his nose was bestraddled by a pair of green spectacles.

" Ladies and gentlemen," said the mystic professor, " I shall have the honour of convincing you this day, that my single hand is more than a match for all the sharp eyes of Overton. You will admit that a beautiful eye makes silence eloquent, a kind eye, contradiction an assent, and an enraged eye, beauty deformed; but my hand shall, by its magic influence, make eloquence dumb, assent a contradiction, and deformity beautiful."

So saying, the professor beckoned a villager, who sat near the stage, to approach and assist him in the performance of his first grand trick.

" Dobby," exclaimed his terrified wife, " sit thee still; that man has dealings with the old one; I would not that he should touch your garment for all the gingerbread in the fair."

This exclamation of the terrified wife set the whole audience in a roar, and produced a confusion which the skilful conjuror is always anxious to create, when any sly work is to be performed. In truth, this scene had been previously concerted by the renowned Crank Smirky, who had engaged this said Dobby as his confederate. A series of very amusing tricks were then performed with cards and counters; such, for instance, as desiring some person to draw a card from the pack, and having observed what it was, to return it; which card, to the wonder of the company, was immediately found in Dobby's pocket. Mr. Seymour informed his children that the explanation of this trick would serve to show the manner in which most of the deceptions on cards were performed. He said, that the conjuror's pack of cards always contained a card, technically termed a '*brief* card,' or 'the *old gentleman*,' which is one made on purpose by the card-maker, and is a little larger than any of the rest; the performer always knows it by feeling it, and can easily force it upon the unsuspecting drawer; should he, however, attempt to take any other, the conjuror, under some pretence, shuffles again, till at length he induces him to take the one intended for him. After the card has been introduced again into the pack, the performer, without any difficulty, withdraws it, and the confederate is called upon to produce the duplicate which had been previously placed in his pocket.

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* See p. 84.

The children were told that the several deceptions with coin, or counters, which they had witnessed, were accomplished by a species of dexterity acquired only by practice, and termed '*palming*;' it consisted in being able to retain a shilling, halfpenny, or counter, in the palm of the hand, while it remained extended; thus the performer desires any one to reckon five pieces, which are accordingly placed on the table before him, the conjuror then takes them up, and having dexterously palmed one, he adds it to the number as he places it in the hand of the unsuspecting person.

Tom and his sisters expressed themselves much pleased and surprised with the dexterity of the performer; "But," added the intelligent boy, "I should be much more gratified by tricks that were indebted for their mystery to some philosophical principle."

Mr. Seymour and the vicar again interchanged looks, that strongly marked the feelings which had been excited by this observation. The former turning to his son, said, that if he waited patiently, he would shortly be gratified in that wish, for he knew Crank Smirky was prepared to exhibit some recreations in divination, that were founded on the science of numbers.

Nor was Mr. Seymour mistaken; for after a few more specimens of his dexterity, the conjuror requested Mr. Twaddleton, who was sitting directly in his front, to take an *even* number of counters in one hand, and an *odd* number in the other; and he would tell him, he said, in which hand he held the even number. Mr. Twaddleton having complied with the request, he was farther desired to multiply the number in the right hand by any *even* number he pleased, as for instance 2; and that in the left hand by an odd number, as 3.

" I have done so," said the vicar.

" Then be pleased to add together the two products, and tell me whether the sum be odd or even."

" It is odd," replied Mr. Twaddleton.

" If so," said the conjuror, " the even number of counters will be in your right hand."

The vicar exposed the counters, and admitted the correctness of the conjuror's decision. (47)

" Ladies and gentlemen," exclaimed the man of mystery, " I now humbly crave your silent attention, while I exhibit one of the most wonderful examples of my art. Here is a ring,—there a shilling,—and there a glove. I shall presently request each of the three gentlemen before me, to take one of those articles, so secretly as to prevent the possibility of my discovering the choice he may have made. I have here, you perceive, twenty-four counters; *one* of which I shall give to you, Mr Seymour; *two* to you, reverend sir; and *three* to you, my young philosopher; the remaining eighteen shall remain on the table. Now, gentlemen, I shall retire, and during my absence, you will be so good as to distribute the three articles in any way you may think proper."

The professor, accordingly, walked off the stage; when Mr. Seymour took the ring; the vicar the shilling; and Tom Seymour the glove. The conjuror, on his return, said that he had one more favour to request, that the person who had the ring should take from the eighteen counters on the table as many as he already possessed; the one with the shilling, twice as many; and the person with the glove, four times as many as he before possessed. The conjuror again retired, in order that the distribution might be made without his observing it. On returning, the conjuror, having first cast his eye upon the counters that remained on the table, informed the company that Mr. Seymour had taken the ring, Mr. Twaddleton the shilling, and the young gentleman the glove. The moment the parties assented to this decision, the whole company expressed their satisfaction and astonishment by thunders of applause.

"That is really very ingenious," observed the vicar.

"How could he perform it?" said Tom: "it is evident that his only guide was the number of counters left on the board."

"I understand the process by which it was accomplished, and will endeavour, at some future time, to explain it," replied Mr. Seymour. (48)

A number of similar tricks followed, all of which depended upon some algebraical calculation; and the performance was concluded to the entire satisfaction of all present.

The next exhibition was of a very different character: it consisted in a variety of optical representations and illusions. The camera obscura presented a moving picture of the surrounding scene. The phantasmagoria exhibited a variety of ghastly objects, which alternately receding from, and approaching the audience, called forth shrieks of terror and amazement. Amongst the most appalling of these figures, was the headless horseman of Sleepy Hollow, so inimitably described in the Sketch Book: it will be remembered that the body of this trooper having been buried in the church-yard, its ghost was believed to ride forth every night in quest of its head, and that the rushing speed with which he passed along the hollow, like a midnight blast, was owing to his being in a hurry to get back to the church-yard before day-break. This rapid movement was admirably represented in the phantasmagoria: at first the figure appeared extremely diminutive, and at a great distance; but almost immediately its size became gigantic, and it seemed as if within a few feet of the audience, and then suddenly vanished. After an instant of utter darkness, the figure was again visible at a great distance: the schoolmaster, Crane, was also seen belabouring the starveling ribs of his steed, old Gunpowder, and quickening his pace towards the very spot where the spectre was stationed. The whole audience were breathless with horror. Crane arrived at the bridge, over which the headless figure opposed his passage. "Mercy upon us!" cried a faint voice from one of the back seats, "the ghost has found his head, and is carrying it before him on the pommel of his saddle."—"Hush, hush," cried another voice; Crane's horse had taken fright; away he dashed through thick and thin; stones flying and sparks flashing at every bound. Crane's flimsy garments fluttered in the air, as he stretched his long lank body away over his horse's head, in the eagerness of his flight. The goblin pressed hard upon him; he was not more than a yard behind him, when he was seen to take up his head, and with gigantic force to hurl it at the pedagogue; it encountered his cranium with a tremendous crash; he was tumbled headlong in the dust; the goblin whisked past like a whirlwind, and the company were once again in total darkness.

"Upon my word," exclaimed Mr. Seymour, "this is one of the most complete illusions I ever witnessed."

"It is most ingeniously managed," said the vicar.

"Papa," cried Tom, "I am quite impatient to learn how so extraordinary an effect can have been produced. You told me this morning that a phantasmagoria was nothing more than an improved magic lantern; but how is it possible for the slides to be so managed as to make the figures approach and retire from you, and above all, to make them move their bodies, and throw their arms into different attitudes?"

"In the first place, the figures only *appear* to approach you, for they are thrown upon a surface which never changes its place; the whole is therefore an optical illusion, arising from the fact that we estimate the distance of an object by its apparent magnitude; when, therefore, the figure began to diminish in size, the mind instantly assumed that it was receding from the eye; and the illusion was still farther heightened by the absence of all other objects* by which it might be compared."

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* It is to this latter circumstance that the Panorama is principally indebted for its magical effects.

At this moment Mr. Seymour was interrupted by the appearance of the performer, who announced his intention of submitting another optical illusion, which, he trusted, would afford equal satisfaction.

"Papa," cried Tom, "how much do I regret my ignorance of optics. It is a great disappointment to me that I should witness so many curious exhibitions, without being able to understand the principles upon which they depend."

"I promise you, my dear boy," replied Mr. Seymour, "that you shall be instructed in this branch of science during the Christmas vacation. Enjoy, therefore, the present amusements, and instead of repining at your ignorance, anticipate the pleasure which you will receive, when you shall be able to explain them."

A series of extraordinary effects were now exhibited by means of concave mirrors.* Aërial images were produced, so illusive in their appearance, that the spectators could not believe in their immateriality, until they attempted to grasp them. In this manner were presented flowers, fruit, a human skull, and a dagger; the latter of which terrified the spectator by the sudden and violent manner in which its point approached him. With this illusion the amusements concluded; the light of day was admitted; and the performer stepping forward, announced the termination of his exhibition in the words of Shakspeare:—

> "Our revels now are ended: these our actors,
> As I foretold you, were all spirits, and
> Are melted into air, into thin air."

The villagers, as they poured out of the booth, and mingled with their companions in the fair, with their wonted propensity for the marvellous, related, in most exaggerated terms, the wonders they had encountered in the region of shadows. Nothing is swallowed with more avidity than tales of mystery, especially if spiced with a few grains of horror; we cannot, therefore, be surprised at the anxiety so generally manifested by those who had not yet witnessed the optical performances to exchange their tickets for such as would secure their admission into the popular booth. The crowd, however, which had assembled round the spot was soon dispersed by the appearance of a placard, announcing the suspension of all the performances for two hours; and informing the populace that the interval would be devoted to various sports and pastimes in the adjoining field.

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* Sir David Brewster has enumerated various extraordinary illusions, which may be thus produced, in his Work on Natural Magic.

The revellers accordingly hastened to the spot where the several sports were to take place, and to which they were directed by the sound of a bugle.

We have stated that a small enclosure had been prepared for the youths of the village, who were to perform the "*ludus Trojæ*," or Troy game. The major and his party had taken possession of the seat, placed for their accommodation under an awning; and the boys classically dressed, and furnished with little arms and weapons, were mustered in the *circo*. Each youth was mounted on a pony; and the troop having rode round the ring, and surveyed the spectators, the vicar arose from his seat, and, like the sage Epytides, gave the signal of attack by a crack of the whip. They now arranged themselves in two battalions, and hurling their javelins with an air of proud defiance, wheeled and charged, and urged the sportive war; at the conclusion of the game, the vicar called the principal youth, or "*princeps juventutis*," and presented him with a basket of fruit, which he desired him to divide amongst his companions.

The populace now separated into different groups; one party proceeded to witness a wrestling-match; another to see the foot-race; a third to be present at a match of quoits; for the vicar had provided all these games, in imitation of the ancient *Penthalum* or *Quinquertium.* While observing the game of quoits, the vicar displayed much classical erudition; he said that Homer had represented Ajax and Ulysses as greatly skilled in the sport; and that Ovid, when he brings in Apollo and Hyacinth playing at it, had given a very elegant description of the exercise.* Scaliger, he continued, is of opinion, that the throwing the *discus,* or quoit, is but an improvement of the old sport of casting the sheep-hook; a conjecture, which, the vicar thought, received some support from a passage in the fourth Iliad.

"Mr. Twaddleton," cried Mr. Seymour, "you look at every sport with the eye of a classic or antiquary; I, on the other hand, as you well know, cautiously examine every action, to discover whether some scientific principle may not find an illustration. On the present occasion, I am desirous of directing the attention of the children to the manner in which yonder skilful player hurls his quoit."

"I do not exactly comprehend the object they have in view in throwing the quoits," said Louisa.

"Do you not perceive that two iron pins, or *hobs,* are driven into the ground, at the distance of eighteen or twenty yards asunder?" asked her father.

"To be sure, and I suppose that each player attempts to hit one of those pins."

"The players stand at one of the *hobs,* and throw an equal number of quoits at the other; the nearest of them to the hob are reckoned towards the game. When they have cast all their quoits, the candidates go over to the point at which they have been throwing, and when they have determined the state of the game, they throw their quoits back again at the hob where they had before stood; and thus continue to act, on alternate sides, till the game is ended."

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* Ovid's Metamorphoses, 10.

"I now understand it," cried Louisa.

"You doubtless know, Mr. Twaddleton," said Mr. Seymour, "that the casting of stones, darts, and other missiles, was among the amusements practised in the twelfth century by the young Londoners."

"*Casting of the bar*," replied the vicar, "was formerly a part of a hero's education; and kings and princes were admired for their agility and grace in throwing 'the stone, the bar, and the plummet.' Henry the Eighth, even after his accession to the throne, retained the casting of the bar among his favourite amusements. The sledge-hammer, and, among rustics, an axle-tree, were also used for the same purpose as the bar and the stone."

"The game of quoits is certainly far superior to such pastimes," said Mr. Seymour, "on account of its depending less on mere strength, and more upon superior skill."

"Did not you say, papa, that its action would illustrate some principle of science? I have been looking at the quoit, which I perceive is a circular piece of iron with a hole in the middle, but I cannot discover in what manner any scientific principle can be connected with its motion."

"If you will attentively observe a skilful player, you will perceive that he steadies the flight of the quoit, by imparting to it a spinning motion; were he not thus to *rifle* it, you would find that it would fly very far from the mark."

"Upon the same principle, I suppose, that we impart to the ball a spinning motion at the game of *bilboquet?*"

"Precisely so," replied her father, who also stated that the body was made to rotate on its shortest axis for the reasons before explained."*

The "*penthalum*" having been concluded, the populace retired into several booths which were appropriated to refreshments. The shows now recommenced; those not already described were principally devoted to the exhibition of wild animals, an entertainment which the vicar considered as sanctioned by the highest classical authority; although he, at once, rejected a proposition made by the major, to render the amusement still more in accordance with ancient custom, by encouraging a fight between a lion and a tiger.

The hour had now arrived for the grand banquet; and, by the command of the major, the band paraded the fair, playing the inviting tune of "Oh, the roast beef of Old England." The populace hastened to the tent, and each took his place according to the number upon his ticket.

We shall not detain our readers by an account of the dinner; it will be sufficient to state, in the language generally used upon such occasions, that the whole went off with great eclat, and gave universal satisfaction to the delighted guests.

For the amusement of his military friends, the major had made arrangements for reviving the ancient game of quintain. It may be necessary to state that the quintain is a pastime of high antiquity. It was originally nothing more than the trunk of a tree, or a post set up for the practice of young beginners in chivalry. Afterwards, a staff or spear was fixed in the earth, and a shield, hung upon it, was the mark to strike at. The dexterity of the performer consisted in smiting the shield in such a manner as to break the fastening and to bring it to the ground. In process of time, this diversion was much improved, instead of the staff and shield, a grotesque wooden figure was introduced, and it was so contrived to move upon a pivot, that if it were struck unskilfully, it would turn out and give the performer a severe blow. The quintain which the major had prepared for the present occasion consisted of a wooden figure, fixed upon a pivot, and holding in its outstretched arm a bag of flour. Those who ran at it, and missed it, were of course laughed at; while those who struck the figure full with his lance gave the beam a sudden whirl; and, unless he was very nimble, was covered with flour from the bag which was thus brought into contact with him.

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* Page 139.

The reader must now be contented to retire from the scene of frolic, and leave the villagers to the undisturbed enjoyment of their jollity. The major and his party returned to the house, where they remained until the hour approached at which the fire-works were to be discharged, and the festivities of the day concluded.

Mr. Seymour accompanied his children to the stage, erected for the pyrotechnic exhibition, in order that he might explain the construction of the fire-works before they witnessed them in action.

"Upon my word, the major has provided most liberally for our entertainment!" exclaimed Mr. Seymour, as he ascended the steps which led to the platform. "I declare there is a forest of *rockets!* and what magnificent *Pin-wheels, Tourbillions, Marroons, Pots des Aigrettes, Gerbes, Courantins,* and *Roman Candles.*"

"Are those paper cylinders, with long sticks, rockets?" enquired Tom.

"They are; and if you will attend to me, I will explain the principle of their construction. They have ever been considered as holding the first place amongst single fire-works, and deservedly so; not only on account of the splendid appearance they present when fired by themselves, but from their extensive application in increasing the beauty of other exhibitions. The rocket, you perceive, consists of a strong paper cylinder, which is filled with a suitable composition; it is crowned with a head, or '*pot*,' as it is technically termed, charged with various materials, which throws out sparks, stars, and other decorations, as soon as it takes fire in the air, after the body of the rocket has been consumed. You may observe that the head is made to terminate in a point, which greatly facilitates its passage through the air. The whole is affixed to a straight stick, which, like the rudder of a ship, makes it turn towards that side to which it is inclined, and consequently causes the rocket to ascend in a straight line."

"But, papa," observed Louisa, "all the rockets have not straight rods; see, there is one with a crooked stick."

"That is for the purpose of causing the rocket to ascend in the form of a screw: the first effect of the bent rod will be to make the rocket incline towards that side to which it is bent; but its centre of gravity bringing it afterwards into a vertical situation, the result of these two opposite efforts will be, that the rocket will ascend in a zig-zag or spiral form. In this case, however, since it displaces a greater volume of air, and describes a longer line, it will not ascend so high as if it had been impelled in a straight direction; but I think you will admit that, on account of the singularity of this motion, it produces a very agreeable effect."

"And what causes the rocket to ascend into the air?" asked Tom.

"That is a question much more readily asked than answered," replied Mr. Seymour: "it is a subject which has engaged the attention of several most distinguished philosophers. I shall first describe to you the theory of Desaguliers. He says, 'Let us suppose that the interior of the rocket were inflamed, and that there were not any vent for the fire; the consequence would be, either that the rocket would burst in the weakest part; or, if all the parts were equally strong, and able to sustain the impulse of the fire, that the rocket would burn out without any motion. Now, as the force is equal in all directions, suppose its action downwards, or that upwards, sufficient to lift forty pounds; as these forces are equal, but their directions contrary, they will destroy each other's action. In the next place, imagine the rocket opened at the choak; in consequence of which the action of the flame downwards is taken away, and there remains a force equal to forty pounds acting upwards, to carry up the rocket, and the stick or rod to which it is attached. We accordingly find that if the composition of the rocket be very weak, so as not to give an impulse greater than the weight of the rocket and its stick, it does not rise at all; or if the composition be slow, so that a small part of it only kindles at first, the rocket will not rise.' Dr. Hutton explains the phenomenon in a somewhat different manner. He says, 'that at the moment when the powder begins to inflame, its expansion produces a torrent of elastic fluid, which acts in every direction; that is, against the air which opposes its escape from the cartridge, and against the upper part of the rocket; but the resistance of the air is more considerable than the weight of the rocket, on account of the extreme rapidity with which the elastic fluid issues through the neck of the rocket to throw itself downwards, and therefore the rocket ascends by the excess of the one of these forces over the other.' "

Tom observed, that he thought Dr. Hutton's explanation more simple and plausible, than that of Desaguliers.

"Dr. Hutton adds," continued Mr. Seymour, "that the rocket could not rise unless a sufficient quantity of elastic fluid were produced, and hence arose the expedient of piercing the rocket with a conical hole, so as to make the composition burn in conical strata, which, having much greater surface, produce a much greater quantity of inflamed matter and elastic fluid. Without such a contrivance, the composition would inflame only in circular coats of a diameter equal to that of the rocket; and experience has shown that this is not sufficient for the purpose."

"What are those fire-works, attached to the lines?" asked Tom.

"Those, my dear, are line-rockets, or *courantines*,* and which, instead of rising into the air, run along the line, to which they are attached by means of a hollow cylinder. Their motion is to be explained upon the same principle as that of the sky-rocket; a force is generated by the escape of elastic matter, and as the rocket is confined to the rope, it is made to run along the line, instead of ascending into the air."

"That is clear enough," said Louisa; "but see, papa, there is the figure of a dragon on yonder rope!"

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* From the French term *courant*, signifying running.

"That is merely a runner for the courantine, which is constructed in that form, for the purpose of rendering the exhibition more surprising. I dare say it is filled with various compositions, such as golden rain, and fires of different colours, which will greatly heighten the effect; indeed this pyrotechnic amusement may be infinitely varied."

"Are not those *pin-wheels,* which are elevated above the railing?" said Tom.

"Yes; they are pin or Catharine wheels, and if you will look at them, you will perceive that they are of very simple construction; consisting merely of a long paper tube, filled with inflammable matter, and rolled round a small circle of wood, so as to form a helix or spiral line."

The circle of wood, I suppose, is pierced in the middle for the purpose of receiving a pin, by which the wheel is attached to the post," said Tom.

"Exactly so; and the cause of their revolution is the same as that which produces the flight of the rocket; the impulse of the air forces back the ignited part of the wheel, which generates, as it were, a centrifugal force, while the attachment of the pipe, by preventing its obeying such a force, may be said to represent the centripetal force, and thus is the revolution of the wheel continued, until the whole of the composition is consumed."

"I think you told us, when speaking of the thaumatrope,* it was the rapidity with which the flame revolved, that occasioned the star-like appearance which is exhibited by this fire-work," observed Louisa.

"Undoubtedly, my dear, it cannot be otherwise."

The party now examined the remaining specimens of the pyrotechnic art. Mr. Seymour informed them that *marroons* were nothing more than small cubical boxes, filled with a composition proper for making them burst, and thence producing a loud report. He said that they were principally used in combination with other pieces, or to form a battery, in which, by different lengths of quick match, they were made to explode at distinct intervals. Mr. Seymour added, that when the cases were made cylindrical, instead of being cubical, they exchanged the name of marroon for that of *saucisson*. Louisa enquired the nature of certain cylindrical cases she observed on the stage, and was informed that they were *gerbes*, a species of fire-work, which throws up a luminous and sparkling jet of fire, and from a supposed resemblance to a water-spout, has derived the appellation of *gerbe*. Mr. Seymour next pointed out to Tom a row of *Roman candles*, some of which were fixed quite perpendicular, others inclining at different angles, so that the balls might be projected to various distances, and thus produce a more varied effect. He observed, that, to his taste, it was by far the most beautiful fire-work ever exhibited.

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* See page 346.

"I am quite impatient for the exhibition," cried Tom; "pray, papa, what is the hour? I think it was determined to let them off at ten o'clock."

"It is now about eight o'clock; we will, therefore, return to the house: we shall, however, I suspect, have a curious sight to witness in our way through the fair; for by this time every booth is illuminated."

The scene was indescribably beautiful, and might be said to resemble an enchanted island. The trees were lighted up with an endless profusion of Chinese lanterns, of various colours, and decorated with fantastic transparencies, which produced an effect highly graceful and pleasing. The booths were richly studded with lights; and, near the platform, on which the villagers were enjoying the country dance, was erected a pyramid, which blazed with several hundred variegated lamps.

At ten o'clock the commencement of the fireworks was announced by a shower of rockets. The music ceased; and the dancers, together with the spectators who had gathered around the platform, hastened to the spot, whither they were summoned by the sound of trumpets, to witness the pyrotechnic entertainment which was to crown the festivities of the day.

The little Seymours had been stationed by their father in the most favourable spot for seeing the exhibition; and highly were the major and his party delighted with the observations which fell from the intelligent children on the occasion.

"Observe, Louisa, the rocket as it ascends describes a parabola,"* cried Tom.

"Oh, how extremely beautiful! see the head has burst, and is discharging a number of brilliant stars! What is that red spark which is now falling to the ground, papa?"

"That is the ignited stick of the rocket," replied his father.

"Take care, Louisa, do not hold your face up," exclaimed Tom; for as the rocket "bursts over our heads, the stick may fall upon us."

"I scarcely expected such an observation from you, Tom," said his father, "after the sensible remark you just made respecting the parabolic path of the rocket; do not you remember that when a projectile has reached its greatest altitude it will descend in a curve similar to that in which it ascended."

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* A scientific critic has offered the following just remark upon this passage. "The rocket ascends by a constantly acting force, not by a momentary impulse, as though it were shot from a gun. Supposing the force arising from combustion to be proportionate to the weight of the rocket, as long as the force continues to be generated, the rocket must move in a straight line; after which, having only its own momentum to oppose to its gravitation, it will proceed in a parabolic curve."

"True, true," answered Tom, "I see my error; the stick must, of course, fall at a considerable distance from us."

"Look! look!! There goes a *courantine*: how it ran along the rope!" exclaimed Louisa.

"There goes another!" cried Tom, "and see, it is the dragon; and, I declare, there is another running in an opposite direction;—they meet. Look at the serpents which they discharge from their mouths. Now they return to the extremity of the line with great violence. What an explosion!!!"

In like manner were next exhibited two ships, which, being filled with serpents, were made to pour their broadsides at each other.

"I never saw better courantines in my life," said Mr. Seymour; "the major really conducts the exhibition with great skill; it does him infinite credit as an engineer."

Another shower of rockets succeeded, and the air resounded with the applause of the populace.

(Bang)—(bang)—(bang)—

"There go the marroons," said Mr. Seymour.

The band now struck up a march, and the major completely succeeded, by having arranged different lengths of quick match, in making them explode at appropriate intervals, so as to mark correctly the commencement of each bar of the music which was performing.

"Bravo! bravo!" exclaimed Mr. Seymour; "had Handel witnessed such an effect, he would have engaged the major as a performer in his grand choruses."

"See! what a beautiful fountain of fire—there! now a most brilliant star is ejected!"—

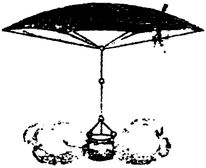
"It is a Roman candle," said Mr. Seymour.

A variety of different rockets were next exploded; such as "*Towering* rockets," so called from their ascending to a greater height than any others; an effect which is produced by fixing a smaller rocket on the top of another of superior dimensions: "*Honorary* rockets," which, when they attain their greatest height, communicate fire to other rockets affixed to them in a transverse direction, and thus produce a rapid revolution, and represent, on their return to the ground, a spiral of descending fire: "*Caduceus* rockets" so called from their resemblance, when in action, to the rod borne by Mercury; the effect is produced by firing two rockets obliquely on the opposite sides of a rod, so that they shall form, in their flight, two spiral lines.

It is not necessary to enumerate the series of beautiful exhibitions which succeeded; we shall only add, that the concluding fire-work was a Catharine-wheel of imposing splendour. After having repeatedly changed its device, during its revolution, it at length exploded and threw out a group of serpents; the dense volume of smoke which followed this explosion, having gradually cleared off, the appropriate motto of "FAREWELL," appeared in brilliant letters of fire.

In a few minutes the populace began to separate; they had, however, scarcely arrived at the gate of the park, when a large rocket ascended, and bursting over their heads, dicharged a parachute, to which was attached a brilliant light; eight similar rockets were successively fired, and with the same effect. The major had ingeniously contrived by varying the angle, to disengage the floating luminaries in the form of a crown or circle, which threw a most brilliant light over the whole country; nor did it fade, until sufficient time had been allowed for the return of the villagers to their respective homes.

Should our readers have fortunately been infected with a portion of that good humour and hilarity which elated the hearts of the spectators upon this memorable occasion, we may conclude our labours with the cheering hope that they will receive a favourable reception at the tribunal of public opinion.



# ADDITIONAL NOTES.

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## REFERRED TO BY FIGURES IN THE TEXT.

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### NOTE 1. p. 5.

THE HOROLOGE OF FLORA is alluded to by Pliny with his usual felicity of thought and expression. "Dedi tibi herbas horarum indices; et ut ne sole quidem oculos tuos a terra avoces, heliotropium ac lupinum circumaguntur cum illo. Cur etiam altius spectas, ipsumque cœlum scrutatis? Habes ante pedes tuos ecce Vergilias."—*Hist. Nat.* lib. xviii. c. 27.

Linnæus enumerates forty-six flowers which possess this kind of sensibility. The following are a few of them, with their respective hours of rising and setting, as the Swedish naturalist terms them. He divides them into *meteoric* flowers, which less accurately observe the hour of unfolding, but are expanded sooner or later, according to the cloudiness, moisture, or pressure of the atmosphere.

2nd. *Tropical* flowers, which open in the morning, and close before evening every day; but the hour of the expanding becomes earlier or later, as the length of the day increases or decreases.

3rd. *Equinoctial flowers*, which serve for the construction of Flora's dial, since they open at a certain and exact hour of the day, and for the most part close at another determinate hour: for instance, the *Leontodon Taraxacum*, dandelion, opens at 5–6, closes at 8–9; *Hieracium Pilosella*, mouse-ear hawkweed, opens at 8, closes at 2; *Tragopogon pratensis*, yellow goat's beard, opens at sunrise, and shuts at noon with such regularity, that the husbandman who adopts it as the signal of dinner-time need not fear to have his pudding too much or too little boiled; *Sonchus lævis*, smooth sow-thistle, opens at 5, closes at 11–12; *Lactuca sativa*, cultivated lettuce, opens at 7, closes at 10; *Tragopogon luteum*, yellow goat's-beard, opens at 3–5, closes at 9–10; *Lapsana*, nipplewort, opens at 5–6, closes at 10–11;

*Nymphæa alba*, white water-lily, opens at 7, closes at 5; *Papaver nudicaule*, naked poppy, opens at 5, closes at 7; *Hemerocallis fulva*, tawny day-lily, opens at 5, closes at 7–8; *Convolvulus*, opens at 5–6; *Malva*, mallow, opens at 9–10, closes at 1; *Arenaria purpurea*, purple sandwort, opens at 9–10, closes at 2–3; *Anagallis*, pimpernel, opens at 7–8; *Portulaca hortensis*, garden purslain, opens at 9–10, closes at 11–12; *Dianthus prolifer*, proliferous pink, opens at 8, closes at 1; *Cichoreum*, succory, opens at 4–5; *Hypocharis*, opens at 6–7, closes at 4–5; *Crepis*, opens at 4–5, closes at 10–11; *Picris*, opens at 4–5, closes at 12; *Calendula Africana*, opens at 7, closes at 3–4, &c.

"Thus in each flower and simple bell,
That in our path betrodden lie,
Are sweet remembrancers who tell
How fast the winged moments fly."

### NOTE 2. p. 33.

It may, perhaps, be asked, how this decrease of weight could have been ascertained; since, if the body under examination decreased in weight, the weight which was opposed to it in the opposite scale must also have diminished in the same proportion; for instance, that if the lump of lead lost two pounds, the body which served to balance it must also have lost the same weight, and therefore that the different force of gravity could not be detected by such means. It is undoubtedly true that the experiment in question could not have been performed with an ordinary pair of scales, but by using a spiral spring it was easy to compare the force of the lead's gravity at the surface of the earth, and at four miles high, by the relative degree of compression which it sustained in those different situations. We may take this opportunity of observing, that as the force of gravity varies directly as the mass, or quantity of matter, a body weighing a pound on our earth would, if transferred to the sun, weigh $27\frac{3}{4}$ pounds; if to Jupiter, $3\frac{1}{10}$ lbs.; if to Saturn, $1\frac{1}{9}$; but, if to the moon, not more than three ounces.

With respect to the effect of the centrifugal force as alluded to in the text, it may be here observed, that it has been found by calculation that, at the equator, the diminution of gravity occasioned by the centrifugal force arising from the rotation of the earth, amounts to about the 289th part. But since this number is the square of

17, it follows, that, if our globe turned more than 17 times faster about her axis, or performed the diurnal revolution within the space of 84 minutes, the centrifugal force would predominate over the powers of gravitation, and all the fluid and loose matters would, near the equinoctial boundary, have been projected from the surface. On such a supposition, the waters of the ocean must have been drained off, and an impassable zone of sterility interposed between the opposite hemispheres. By a similar calculation, combined with that decreasing force of gravity at great distances from the centre, it may be inferred, that the altitude of our atmosphere could never exceed 26,000 miles. Beyond this limit, the equatorial portion of air would have been shot into indefinite space.

### NOTE 3. p. 36.

It is scarcely possible so to strain the imagination as to conceive the velocity with which light travels. "What mere assertion will make any man believe?" asks Sir W. Herschel, "that in one second of time, in one beat of the pendulum of a clock, a ray of light travels over 192,000 miles, and would therefore perform the tour of the world in about the same time that it requires to wink with our eyelids, and in much less than a swift runner occupies in taking a single stride." Were a cannon ball shot directly towards the sun, and it were to maintain its full speed, it would be twenty years in reaching it, and yet light travels through this space in seven or eight minutes.

### NOTE 4. p. 37.

In order to perform this experiment with the highest degree of accuracy, a body of considerable specific gravity should be selected, such as lead or iron; for a common stone experiences a considerable retardation in falling, from the action of the air. Where the arrival of the body at the bottom of the cavern to be measured cannot be *seen*, we must make allowance in our calculation for the known velocity of sound; thus, suppose a body were ascertained to fall in five seconds. As a heavy body near the earth's surface falls about $16\frac{1}{12}$ feet in one second of time, or for this purpose 16 feet will be sufficiently exact; and as sound travels at the rate of 1142 feet per second, multiply together 1142, 16 and 5, which will give 91360, and to four times this product, or 365440, add the square of 1142, which is 1304164, and the sum will be 1669604;

then if from the square root of the last number = 1292 the number 1142 be subtracted, the remainder 150 divided by 32 will give 4·69 for the number of seconds which elapsed during the fall of the body; if this remainder be subtracted from 5, the number of seconds during which the body was falling and the sound returning, we shall have 0·31 for the time which the sound alone employed before it reached the ear; and this number multiplied by 1142, will give for product 354 feet equal the depth of the well. This rule, which, it must be allowed, is rather complex, is founded on the property of falling bodies, which are accelerated in the ratio of the times, so that the spaces passed over increase in the square of the times.

The following is a more simple but less accurate rule. Multiply 1142 by 5, which gives 5710; then multiply also 16 by 5, which gives 80, to which add 1142, this gives 1222, by which sum divide the first product 5710, and the quotient 4·68 will be the time of descent, nearly the same as before. This taken from 5, leaves 0·32 for the time of the ascent; which, multiplied by 1142, gives 365 for the depth, differing but little from the former more exact number.

## NOTE 5. p. 40.

This superstition still prevails in many parts of England, especially in Cornwall, where the peasants on certain days of the year assemble at the springs, or holy wells, and in the manner stated in the text, proceed to settle such doubts and enquiries as will not let the idle and anxious rest. Here, therefore, they come, and, instead of allaying, deservedly feed their uneasiness; the supposed responses serving equally to increase the gloom of the low-spirited, the suspicions of the jealous, and the passion of the enamoured. The superstition, however, is sanctioned by the highest antiquity. The Castalian fountain, and many others among the Grecians, were supposed to be of a prophetic nature. By dipping a fair mirror into a well, the Patræans of Greece received, as they supposed, some notice of ensuing sickness or health, from the various figures portrayed upon the surface. In Laconia they cast into a pool, sacred to Juno, cakes of bread-corn: if they sank, good was portended; if they swam, something dreadful was to ensue. Sometimes they threw three stones into the water, and formed their conclusions from the several turns they made in sinking. "From the several waves and eddies, which the sea, river, or other water exhibited," says Dr. Borlase, "when put into agitation after a ritual manner, the ancients pretended to foretell with great certainty the event of battles; a way of divining recorded by Plutarch, in his life of Cæsar, and still usual among the vulgar in Cornwall; who go to some noted well, at particular times of the year, and there observe the bubbles that rise, and the aptness of the water to be troubled, or to remain pure, on their throwing in pins or pebbles, and thence conjecture what shall, or shall not befall them. The Druids also, as we have great reason to think, pretended to predict future events, not only from holy wells, and running streams, but from the rain and snow water, which, when settled, and afterwards stirred, either by oak-leaf or branch, or magic wand, might exhibit appearances of great information to the quick-sighted Druid, or seem so to do to the credulous enquirer, when the priest was at full liberty to represent the appearances as he thought most for his purpose."—BORLASE's *Antiquities of Cornwall*, p. 140.

### NOTE 6. p. 44.

The Latin word *moneta*, for money, is probably more modern than *pecunia*, and is said to be derived from *moneo*, to advise or mark, that is, to show by some mark the weight and fineness of the metal of which coins were composed. Thus, according to Isidorus, "Moneta ita appellatur, quia monet nè qua fraus in pondere vel metallo fiat." The origin of money seems to have been coeval with the first regulations of civil society, or, at least, it is too remote to be traced by any authentic history. Barter, that is the exchange of one commodity for another, was the ordinary mode of traffic in the earlier periods of the world; a practice which must soon have been discovered extremely inconvenient, and inadequate to the purposes of commerce; and hence the invention of a common measure, or standard, according to which all other things should be estimated. Writers very generally agree in believing that the metals were first used for such a purpose, as being almost the only substances, whose goodness, and, as it were integrity, were not injured by partition; and which admitted of being melted, and returned again into a mass of any size or weight. At first, it is probable, that each person cut his metal into pieces of different sizes and forms, according to the quantity to be given for any merchandize, or according to the demand of the seller, or the quantity stipulated between them; to this end they went to market, laden with metal, in proportion to the purchase to be made, and furnished with instruments for apportioning it, and with scales for dealing it out, according as occasion required. By degrees it must have been found commodious to have pieces ready weighed; and Mr. Pinkerton observes that such were prepared without any stated form or impression, but merely regulated to a certain weight; for *weight* was the grand standard of ancient coinage, so that all large sums were paid in weight, even down to the Saxon period of England. As in Greece the first estimation of money was merely by weight, so was it in Rome. Silver was the metal first used in Grecian coinage, but copper in the Roman; the former metal having been long unknown to the Romans. The first valuation of Roman money was by the *libra gravis æris*, or pound of heavy brass: and when by the progress of their conquests they obtained silver and gold, these were regulated in the same manner. Let us proceed one step farther in the history of coins; it is easy to imagine that the growing commerce of money being disturbed with frauds, both in the weight and the material, the interposition of public authority became necessary, and that hence arose the first stamps or impressions of money; to which succeeded the names of the moneyers, and at length the effigy of the prince, the date, legend, and other precautions to prevent the alteration of the species; and thus were coins completed. Gold and silver, in their pure or unmixed state, are too flexible to make coins sufficiently firm for general use; and hence the necessity of mixing with them a certain proportion of some harder metal, and this mixture is called the *alloy*. The quality of this alloy has been always considered of great importance with respect to the durability of coins. The most common metal used for this purpose is copper; and sometimes, for gold, a mixture of silver and copper. In all well-regulated governments, there has been a standard fixed by law; that is, a certain proportion between the quantity of pure metal and its alloy. In England the standard for gold is $\frac{11}{12}$, that is eleven parts of pure metal, and one part of alloy. The standard for silver is $\frac{37}{40}$, a proportion which is said to have been fixed in the reign of Richard I. by certain persons from the eastern parts of Germany, called *Easterlings*; and hence the word *Sterling*, which was afterwards the name given to the silver penny, and which is now applied to all lawful money of Great Britain.

*Penny* is derived by Camden from *pecunia*, but others suppose that the word is formed from *pendo* to weigh, and the word has been sometimes written, according to this origin, *pending*. The ancient English penny, or penig, or pening, was the first silver coin struck in England, and the only one current amongst our Saxon ancestors. Until the time of Edward I. the penny was struck with a cross so deeply indented in it that it might be easily broken, and parted into two pieces, thence called *half-pennies*, or into four, called *four-things*, or *farthings*; but that Prince coined it without indenture; in lieu of which he first struck round half-pence and farthings.

By the term MEDAL, we understand a piece of metal, in the form of a coin, destined to preserve to posterity the portrait of some great man, or the memory of some illustrious action. They are distinguished by their different sizes; those of the larger size, or volume, are called *medallions*. *Medallets* is a name given by Pinkerton to those small pieces, or *missilia*, scattered among the people on solemn occasions; those struck for the slaves in the Saturnalia, private counters for gaming, tickets for baths and feasts, tokens in copper and lead, and the like. Medallions were certainly never intended to become current coin, as some medals probably were; they were struck purely to serve as public monuments, or to be presented by the emperor to his friends, and by the mint-makers to the emperor, as specimens of fine workmanship. They were struck upon the commencement of the reign of a new emperor, and other solemn occasions; and frequently, especially the Greek medallions, as monuments of gratitude, or of flattery. Sometimes they were trial or pattern pieces, *testimonia probatæ monetæ*; and such abound after the reign of Maximilian, with the "Tres monetæ" on the reverse. It is observed, that all the Roman pieces in gold, exceeding the *denarius aureus*; all in silver, superior to the *denarius*; and all in brass, superior to the *sestertius*, or what the medallist terms large brass, are comprehended under the description of medallions. Mr. Pinkerton, however, thinks that the gold medallions, weighing two, three, or four aurei only, passed in currency according to their size. Medallions from the time of Julius to that of Adrian, are very uncommon, and of very high price; from Adrian to the close of the western empire they are, generally speaking, less rare. The types of the Roman medallions are often repeated upon common coin; hence they appear of less importance than the Greek;

impressions of which are frequently most uncommon, and nowhere else to be found. Many Roman medallions have S. C., as being struck by order of the senate; those without these initials, were struck by order of the emperor. Of Augustus, a noble medallion was found in Herculaneum. There are medallions of Augustus and Tiberius, struck in Spain; and one of Livia, at Patræ in Achaia. One in brass, of Antony and Cleopatra; reverse, two figures in a car, drawn by sea-horses. Of Tiberius there are many; and also of Claudius, Agrippina, Nero, Galba, Vespasian, and Domitian, &c. The Greek medallions of Roman emperors are far more numerous than the Roman; with a few exceptions, however, all medallions are rare and of princely purchase. Even in the richest cabinet, twenty or thirty specimens are esteemed a respectable proportion.

The parts of a medal are the two sides, one whereof is called the *face*, *head*, or obverse; the other the *reverse*. On each side is the *area*, or *field*; the *rim*, or *border*; and the *exergum*, which is beneath the ground, whereon the figures represented are placed. On the two sides are distinguished the *type*, and the *inscription*, or *legend*. The type, or device, is the figure represented; the legend is the writing, especially that around the medal; though in the Greek medals the inscription is frequently on the area. What we find in the exergum is, generally, no more than some initial letters, whose meaning we are usually unacquainted with; though, sometimes, they contain words that may be accounted an inscription.

The exergum sometimes contains the date of the coin, expressing in what consulship of the emperor it was struck, as Cos. III. upon the reverse of an Antoninus. Sometimes it signifies the place where it was struck, and to which the coin properly belonged, as S. M. AL. for *Signa Moneta Alexandriæ*, upon the reverse of a Licinius. Sometimes the name of a province, the reduction of which the medal is designed to celebrate; as Judæa on the reverse of a Vespasian.

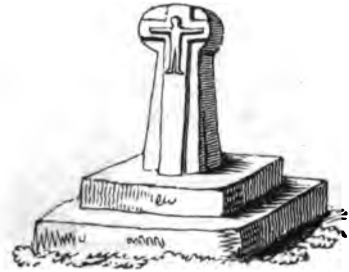
We have stated that medals are of great importance to the study of history. They, indeed, furnish the principal proof of historic truth, as their evidence reaches to the most remote ages, as well as to the most remote countries. Vaillant, in his learned history of the Syrian kings, printed at Paris, 1681, first fixed the dates, and arranged the order of events in ancient historians, by means of these infallible vouchers. Thus he was enabled to ascertain the chronology and progress of events of three of the most important kingdoms of the ancient world; viz. those of Egypt, of Syria, and of Parthia. The study of the Roman medals has, in this respect, an advantage over that of Greek coins, since they serve not only to illustrate the chronology of reigns, but to aid us in the interpretation of particular events. To this purpose, besides the portrait of the prince, and date of his consulship, or of his tribunitian power, we have a representation, or poetical symbol, of some grand event on the reverse. In a word, the series of Roman coins presents the very best suite of documents relating to the Roman History. In addition to its historical importance, the medal is frequently a useful guide to geography, natural history, architecture, ancient monuments, busts, statues, ceremonies, and the like. See Addison's *Dialogues on the Usefulness of Ancient Medals.* On this subject, also, Pinkerton, in his valuable work on medals, has some interesting remarks; he says that, to a man of poetical imagination, the Roman coins must prove an ample source of intellectual delight, by means of the fine personifications and symbols which are to be found on their reverse. *Happiness* has sometimes the caduceus, or wand of Mercury, which Cicero tells us was thought to procure the gratification of every wish. In a gold coin of Severus, she has heads of poppy to express that our prime bliss lies in oblivion of misfortune. *Hope* is represented as a sprightly damsel, walking quickly and looking straightforward. With her left hand she holds up her garments, that they may not hinder the rapidity of her pace; while, in her right hand, she holds forth the bud of a flower, an emblem infinitely more beautiful than the trite one of an anchor, which is the symbol of Patience, not of Hope. *Abundance* is imagined as a sedate matron, with a cornucopiæ in her hands, of which she scatters the fruits over the ground: but does not hold it up, and keep its contents to herself, as many poets and painters have represented her. *Security* stands leaning on a pillar, indicative of her being free from all designs and pursuits; and the posture itself corresponds to her name.

Coins also present us with countries and rivers admirably personified. On the reverse of a colonial coin, rude in execution, of Augustus and Agrippa, inscribed IMP. and DIVI. F., the conquest of Egypt is represented by the apposite metaphor of the crocodile, an animal almost peculiar to that country, and at that period esteemed altogether so, which is chained to a palm tree, at once a native of the country, and symbolic of victory. Moreover, a cabinet of medals, of which Rubens is said to have possessed a very magnificent one, may be considered as forming the classic erudition of a painter. We may add, that almost all the uses which connect the science of medals with painting, render it also subservient to the art of the sculptor, who cannot less than profit by the study of the Greek coins in particular. The connexion of the study of ancient coins with architecture, consists in the views of many of the ancient edifices, which are found in perfect preservation on medals. Froelich observes, that the coins of Tarsus are very remarkable for a kind of perspective in the figures. On others are found triumphal arches, temples, fountains, aqueducts, amphitheatres, circuses, palaces, columns, obelisks, baths, sea-ports, pharoses, and the like.

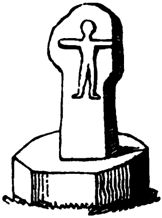
The study of medals affords such a variety of amusement and of instruction, that we may naturally suppose it to be nearly as ancient as medals themselves; and yet ancient writers do not furnish us with a single hint of collections of this kind. In the days of Greece, a collection of such coins as then existed would not be regarded as an acquisition of any great value, because it must have consisted only of those that were struck by the innumerable little states which then used the Greek characters and language, and of course it would be considered as a kind of domestic coinage, precluded from extension by the narrow limits of the intercourse that subsisted between different provinces and countries. As soon as any communication was opened between the Romans and the Greeks, the Grecian coins were imitated by the Roman workmen, and preserved in the cabinets of their senators among the choicest treasures. In a more advanced period of the Roman empire, individuals must have formed collections of Roman coins; for we find that a complete series of silver was lately found in our island, containing inclusively, all the emperors down to Carausius. From the decline of the Roman empire, most branches of science were enveloped in darkness, till the revival of letters towards the end of the fifteenth century. When literature began to be cultivated in Italy, the study of medals, connected with that of ancient erudition, began to engage attention. Accordingly Petrarch, who in modern times was amongst the first persons in Europe that aspired to the celebrity of learning and genius, was likewise the first to revive the study of medals. This eminent man, having been desired by the Emperor Charles V. to compose a book that should contain a history of the coins of illustrious men, and to place him in the list, is said to have returned for answer, that he would comply with his desire, whenever the Emperor's future life and actions deserved it. Availing himself of this circumstance, he sent that monarch a collection of gold and silver coins of celebrated men. "Behold!" said he, "to what men you have succeeded! Behold whom you should imitate and admire! to whose very form and image you should compose your talents! The invaluable present I should have given to no one but yourself; it was due to you alone. I can only know or describe the deeds of these great men: your supreme office enables you to imitate them." In the next age, Alphonso, king of Arragon, caused all the ancient coins that could be discovered throughout the provinces of Italy to be collected, which he placed in an ivory cabinet, and always carried about with him, that he might be excited to great actions by the presence, as it were, of so many illustrious men in their images.

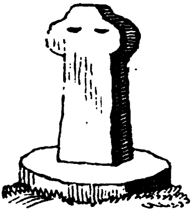
To those who are desirous of gaining information upon this interesting branch of antiquarian research, we strongly recommend Mr. Pinkerton's *Essay on Medals*.

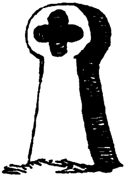
Having been led to offer these observations on ancient medals, we may, perhaps, be allowed to make one other digression on a subject naturally suggested by a visit to the vicarage of our reverend antiquary. The reader has been told, that "around his house he had arranged several precious relics, amongst which was an ancient cross, raised upon a platform on three steps." We have been fortunate enough to obtain a sketch of this interesting remnant of antiquity, and we shall here present it to our readers.

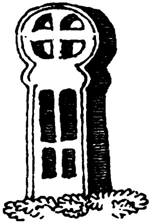


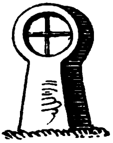
There is much obscurity with regard to the origin and uses of these stone crosses. We are, however, not disposed to enter into a discussion of such difficulty; but the reader may be gratified in having presented to him, in one view, a collection of such crosses as still exist in various parts of Cornwall.

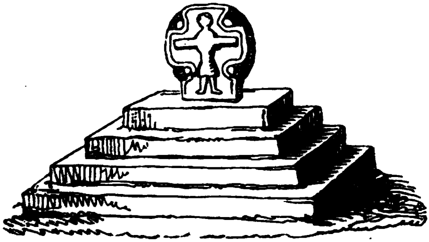












## NOTE 7. p. 50.

Upon this subject, the reader is requested to turn to page 139, where it is stated that a body will permanently rotate only on its shortest axis. The philosophy of the fact is simply this—while a body revolves on its axis, the component particles of its mass move in circles, the centres of which are placed in the axis; a centrifugal force therefore is generated, which is resisted by the cohesion of the parts of the mass, and this tendency of each particle to fly off is expended in exciting a pressure upon the axis; and it is this strain which produces the effect in question, the axis of no pressure being alone the permanent axis.

## NOTE 8. p. 62.

Mechanical powers are simple arrangements by which we gain power at the expense of time; thus, if a certain weight can be raised to a certain height by unassisted strength, and the same thing is afterwards done with one tenth part of the exertion, through the use of a mechanic power, it will be found to occupy ten times as much time. In many cases, however, loss of time is not to be put in competition with the ability to do a thing; and since the advantages which the mechanical powers afford to man, by enabling him to perform feats which, without their assistance, would have been for ever beyond his reach, are incalculably great, the waste of time is overlooked, and is much more than balanced in the general result. It is true, that if there are several small weights, manageable by human strength, to be raised to a certain height, it may be full as convenient to elevate them one by one, as to take the advantage of the mechanical powers in raising them all at once; because the same time will be necessary in both cases: but suppose we should have an enormous block of stone, or a great tree to raise; bodies of this description cannot be separated into parts proportionable to the human strength, without immense labour, nor, perhaps, without rendering them unfit for those purposes to which they are to be applied; hence then the great importance of the mechanical powers, by the use of which a man is able to manage with ease a weight many times greater than himself.

To understand the principle of a mechanical power, we must revert to the doctrine of momentum. It will be remembered, that a small ball, weighing only two pounds, and moving at the rate of 500 feet in a second, will produce as much effect as a cannon ball of ten pounds in weight, provided it only moved at the rate of 100 feet in the same time; in like manner a ball weighing one pound may be made to balance another of five pounds, by placing it five times farther from the centre of motion; for in such a case, for every inch of space through which the large ball passes, the small one will traverse five inches, and will thus generate five times the momentum. This may be rendered still more evident by turning to page 162, and note thereon, where the *see-saw* is described, which, in fact, is a true mechanical power. It will be at once evident, from an inspection of the figure, that the lesser boy will pass over a much greater space, in equal time, than the greater boy, and thus generate more momentum, which compensates for his defect in weight, and renders him a balance for his heavier companion.

### NOTE 9. p. 76.

Those who have been in the habit of inspecting the works of the statuary, must frequently have detected the art which he has displayed in imparting stability to his figures, by lowering their centre of gravity. The bronze figure of Achilles, in Hyde Park, affords a very striking illustration of such ingenuity; it is evident, from the position and height of the figure, that, had not a mass of matter been added to its base, its stability would have been extremely precarious, since the slightest movement might have thrown its line of direction beyond the base; but the addition at the base renders such an accident impossible, by lowering its centre of gravity. Other examples of similar contrivance are presented in several celebrated statues, wherein stability is ensured by the judicious distribution of the draperies. In the celebrated statue of Peter at St Petersburgh, the equilibrium of the mass is thus sustained by the introduction of a serpent; nor have our celebrated painters overlooked a principle, the neglect of which would have withheld from the most symmetrical figures the charms of beautiful proportion.

### NOTE 10. p. 93.

"When a native of Macoushi goes in quest of feathered game, or other birds, he seldom carries his bow and arrows. It is the *blow-pipe* he then uses. This extraordinary tube of death is, perhaps, one of the greatest natural curiosities in Guiana. It is not found in the country of Macoushi. Those Indians tell you that it grows to the south-west of them, in the wilds which extend betwixt them and the Rio Negro. The reed must grow to an amazing length, as the part the Indians use is from ten to eleven feet long, and no tapering can be perceived in it, one end being as thick as the other. It is of a bright yellow colour, perfectly smooth both inside and out. It grows hollow; nor is there the least appearance of a knot or joint throughout the whole extent. The natives call it *ourah*. This, of itself, is too slender to answer the end of a blow-pipe; but there is a species of palma, larger and stronger, and common in Guiana, and this the Indians make use of as a case, in which they put the *ourah*. It is brown, susceptible of a fine polish, and appears as if it had joints five or six inches from each other. It is called *samourah*, and the pulp inside is easily extracted, by steeping it for a few days in water. Thus the ourah and samourah, one within the other, form the blow-pipe of Guiana. The end which is applied to the mouth is tied round with a small silk-grass cord, to prevent its splitting; and the other end, which is apt to strike against the ground, is secured by the seed of the acuero fruit, cut horizontally through the middle, with a hole made in the end, through which is put the extremity of the blow-pipe. It is fastened on with string on the outside, and the inside is filled up with wild bees-wax. The arrow is from nine to ten inches long. It is made out of the leaf of a species of palm-tree, called *coucourite*, hard and brittle, and pointed as sharp as a needle. About an inch of the pointed end is poisoned with the *wourali*. The other end is burnt, to make it still harder, and wild cotton is put round it for about an inch and a half. It requires considerable practice to put on this cotton well. It must just be large enough to fit the hollow of the tube, and taper off to nothing downwards. They tie it on with a thread of the silk grass, to prevent its slipping off the arrow.

"The Indians have shown ingenuity in making a quiver to hold the arrows. It will contain from five to six hundred. * * * * * *

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With a quiver of poisoned arrows slung over his shoulder, and with his blow-pipe in his hand, in the same position as a soldier carries his musket, see the Macoushi Indian advancing towards the forest in quest of powises, maroudis waracabas, and other feathered game.

"These generally sit high up in the tall and tufted trees, but still are not out of the Indian's reach; for his blow-pipe, at its greatest elevation, will send an arrow 300 feet. Silent as midnight he steals under them, and so cautiously does he tread the ground, that the fallen leaves rustle not beneath his feet. His ears are open to the least sound, while his eye, keen as that of the lynx, is employed in finding out the game in the thickest shade. Often he imitates their cry, and decoys them from tree to tree, till they are within range of his tube. Then taking a poisoned arrow from his quiver, he puts it in the blow-pipe, and collects his breath for the fatal puff. About two feet from the end through which he blows, there are fastened two teeth of the acouri, and these serve him for a sight. Silent and swift the arrow flies, and seldom fails to pierce the object at which it is sent. Sometimes the wounded bird remains in the same tree where it was shot, and in three minutes falls down at the Indian's feet. Should he take wing, his flight is of short duration, and the Indian, following the direction he has gone, is sure to find him dead. It is natural to imagine that, when a slight wound only is inflicted, the game will make its escape. Far otherwise; the wourali poison almost instantaneously mixes with blood or water, so that if you wet your finger, and dash it along the poisoned arrow in the quickest manner possible, you are sure to carry off some of the poison. Though three minutes generally elapse before the convulsions come on in the wounded bird, still a stupor evidently takes place sooner, and this stupor manifests itself by an apparent unwillingness in the bird to move.

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"The Indian, on his return home, carefully suspends his blow-pipe from the top of his spiral roof; seldom placing it in an oblique position, lest it should receive a cast."—WATERTON'S *Wanderings in South America*, p. 58.

### NOTE 11. p. 97.

A clock is nothing more than a piece of machinery to maintain the action of the pendulum, and at the same time to count and register the number of its oscillations; and by that peculiar property, that one vibration commences exactly where the last terminates, no part of time is lost or gained in the juxtaposition of the units so counted.

If some extraneous force were not applied, in a clock or watch, to maintain or perpetuate the natural vibrations of a pendulum, or oscillations of a balance, they would soon come to rest, by reason of friction in the mechanism, and the resistance opposed by the air to the parts in motion. This force, in the larger clocks, is usually a suspended weight; but, in the portable clock and watch, it is a spring coiled in a metallic box, that actuates the wheel-work by gradually unbending itself.

In the former of these cases, the weight is suspended by a cord or chain that is coiled round a cylinder when wound up, which cylinder being of uniform diameter throughout its length, is acted on by the cord, when fast at the interior end, by a similar force in every situation; and, therefore, imparts through the train, connected with its great wheel, invariable impulses to the escapement-wheel, at every vibration of the pendulum; which pendulum receives therefrom such a slight push, as is just sufficient to restore the momentum which it loses from friction and the air's resistance, and thus the uniform motion of the pendulum is perpetuated. But when a spring is substituted for a weight, it is clear that its agency cannot be uniform, since, as the reader will learn by turning to page 101, it is a general law that elastic bodies, in the recovery of their form, after the removal of the compressing force, exert a greater power at first than at last, so that the whole progress of restoration is a *retarded* motion. It, therefore, became necessary to introduce some mechanical contrivance which might equalize such motion. This correction is effected by an apparatus termed a FUSEE, and is nothing more than the application of the wheel and axle; it is that conical barrel seen in most watches round which the chain coils in the act of winding up. When the fusee is full of chain, or the watch is wound up, the spring, through the medium of the chain, will act upon its upper part, which being very near the centre will give the spring but little power; but, as the spring uncoils and diminishes in strength, it will act upon a larger part of the fusee, until at last it gets to the bottom of it, and consequently, if the several increasing grooves upon it are made to increase in the same proportion as the power of the spring decreases, an equable force must be obtained

Springs may be thus said to afford the means of *packing up* force, to be used whenever it is required. Mr. Babbage observes that the half minute which we daily devote to the winding up our watches is an exertion by which we *pack* a quantity of force, which is gradually expended during the ensuing twenty-four hours. Springs then will enable us to avail ourselves of inconstant and variable forces which must otherwise remain incapable of useful application, and the period may arrive when force will thus become an article of traffic, and machines be sent to the windmill to be wound up.

### NOTE 12. p. 97.

The elastic property of iron springs has been lately exemplified in a very striking manner, by the invention of Pratt's elastic chairs and beds; which, instead of the usual stuffing of feathers, are filled with iron wire!!! which is twisted into spiral form. Down itself cannot be more gentle or springy; it yields to pressure, and yet never becomes lumpy: beds thus constructed have the advantage of not heating the body; and above all, they never require to be shaken or "made." Had Vulcan fortunately made such a discovery before his ejectment from Olympus, his wife, Venus, would surely never have treated him with that contempt which mythologists have recorded of her; while her priestesses, the housemaids, must, in gratitude, have been bound to extend their protection to a benefactor, who could save them so much daily labour. For particulars of this curious invention, the reader may consult the *Literary Gazette* for March 17, 1827.

### NOTE 13. p. 98.

The phenomenon has been explained as depending upon the inertia of the parts of matter, which renders a certain time necessary in order to communicate to any body a sensible motion; so that when a body, moving with considerable velocity, meets with another of much greater size, it experiences almost as much resistance as if the latter were fixed. Nothing is easier to be divided than water; yet, if the palm of the hand be struck with some velocity against its surface, a considerable degree of resistance, and even of pain, is experienced from it, as if a solid body had been struck; nay, a musket-ball, when fired against water, is repelled and even flattened by it. In like manner, if we load a musket with powder, and instead of a ball, introduce a candle, and fire it against a board, the latter will be pierced by the candle end, as if by a ball. The cause of this phenomenon, no doubt, is that the rapid motion with which the candle end is impelled, does not allow it time to be flattened, and therefore it acts as a hard body.

### NOTE 14. p. 99.

*Impatiens*, or *Touch me not*, affords a good example. The seed-vessel consists of one cell with five divisions; each of these, when the seed is ripe, on being touched, suddenly folds itself into a spiral form, leaps from the stalk, and disperses the seeds to a great distance by its elasticity. The capsule of the geranium and the beard of wild oats are twisted for a similar purpose. (DARWIN'S *Botanic Garden.*) The seed-vessel of euphorbia is extremely elastic, projecting the seeds with great force. An elastic pouch also serves to scatter the seeds of the oxalis.

### NOTE 15. p. 126.

A very instructive toy might be constructed by placing a taper in the centre of a japanned waiter, to represent the sun, and fixing in a watch glass an indian rubber ball, with the parallels of latitude and meridians painted thereon, with the other characters of the globe. During its revolution around the candle, in consequence of the tendency of its centre of gravity to its lowest position, the diurnal and annual motions, and also the parallelism of its axis will be represented, together with the concomitant phenomena.

### NOTE 16. p. 131.

If a cone, or sugar-loaf, be cut through in certain directions, we shall obtain figures which are termed *conic sections;* thus, if we cut through the sugar-loaf in a direction parallel to its base, or bottom, the outline or edge of the loaf where it is cut will be a *circle.* If the cut is made so as to slant, and not be parallel to the base of the loaf, the outline is an *ellipse*, provided the cut goes quite through the sides of the loaf all round; but if it goes slanting, and parallel to the line of the loaf's side, the outline is a *parabola*, a conic section, or curve, to which this note more immediately relates. This curve is distinguished by characteristic properties, every point of it bearing a certain fixed relation to a certain point within it, as the circle does to its centre.

### Note 17. p. 135.

During the dreadful earthquake of Lisbon, bands of wretches took advantage of the general consternation to commit the most atrocious acts of robbery and murder. In fact a considerable part of the city was destroyed by incendiaries, who, during the disaster, set fire to the houses, that they might pillage them with greater impunity.

### Note 18. p. 136.

Soils consist of a mixture of different finely divided earthy matter, with animal or vegetable substances in a state of decomposition. In order, therefore, to form a just idea of their nature, it is necessary to conceive different rocks decomposed, or ground into parts and powder of different degrees of fineness; some of their soluble parts dissolved by water, and that water adhering to the mass, and the whole mixed with larger or smaller quantities of the remains of vegetables and animals, in different stages of decay. Hence it will follow, that certain rocks will give origin to particular soils; thus poor and hungry soils, such as are produced from the decomposition of granite and sandstone, remain very often for ages with only a thin covering of vegetation; while soils from the decomposition of limestone, chalk, and basalt, are often clothed by nature with the perennial grasses; and afford, when ploughed up, a rich bed of vegetation for every species of cultivated plant. In adverting to this subject, Dr. Buckland, in his inaugural lecture, very justly observes, that it furnishes an instance of relation between the vegetable and mineral kingdoms, and of the adaptation of one to the other, which always implies design in the surest manner; for had not the surface of the earth been thus prepared for their reception, where would have been the use of all that admirable system of organization bestowed upon vegetables? And it is no small proof of design in the arrangement of the materials that compose the surface of our earth, that whereas the primitive and granitic rocks are least calculated to afford a fertile soil, they are for the most part made to constitute the mountain districts of the world, which, from their elevation and irregularities, would otherwise be but ill adapted for human habitation; whilst the lower and more temperate regions are usually composed of derivative or secondary strata, in which the compound nature of their ingredients qualifies them to be of the greatest utility to mankind by their subserviency to the purposes of luxuriant vegetation.

No doubt, then, can exist as to the important connexion between the geological structure of a country, and its degree of fertility; but the subject has not received the attention which it merits. Geological memoirs abound with hints and scattered notices, but we believe that, with the exception we are about to notice, there does not exist any memoir which professes to describe the different rocks in a neighbourhood, with a view to trace the variations in its soils according to the change of the substrata. The essay to which we allude, is a paper published in the first volume of the Transactions of the Royal Geological Society, entitled "*Observations on the Geological Structure of Cornwall, with a view to trace its connexion with, and influence upon its agricultural economy, and to establish a rational system of improvement by the scientific application of mineral manure.*" We shall extract some passages from this paper, in order to confirm the assertion made in the text. "There is certainly no district in the British empire where the natural relations between the varieties of soil and the subjacent rocks can be more easily discovered and traced, or more effectually investigated, than in the county of Cornwall; and no where can the information, which such an enquiry is calculated to afford, be more immediately and successfully applied for the improvement of waste lands, and the general advancement of agricultural science.

"As we advance from a primitive to an alluvial district, the relations to which we have alluded become gradually less distinct and apparent, and are ultimately lost in the confused complication of the soil itself, and in that general obscurity which necessarily envelopes every object in a state of decomposition: we can, therefore, only hope to succeed in such an investigation by a patient and laborious examination of a primitive country, after which we may be enabled to extend our enquiries with advantage through those districts which are more completely covered with soil, and obscured by luxuriant vegetation; as the eye gazing upon a beautiful statue, traces the outline of the limbs, and the swelling contour of its form, through the flowing draperies which invest it. The county of Cornwall may be said to consist of four primary rocks, each of which, by decomposition, gives origin to a peculiar soil, distinct in its nature and characters, and requiring an appropriate system of cultivation and improvement. They all, however, agree in one essential particular—their earthy combinations are few and simple; the great object of art, therefore, is to extend and multiply them, and thereby to increase and diversify their chemical and mechanical agencies. In alluvial districts the very contrary obtains, for Nature has already mixed and compounded the different particles of rocks in every proportion, and in every manner, and has therefore left but little to be effected by the suggestions of science, or the resources of art. The principal rocks of which Cornwall consists are granite, slate, hornblende rocks, and serpentine. Beds of limestones, dykes of porphyry, veins of quartz, and those of other minerals, will also claim a portion of our attention, inasmuch as they produce an influence upon the soils beneath which they occur.

"Granite forms the skeleton of the county, upon which all the other formations repose; the soil to which its disintegration gives origin, is provincially termed a *growan soil;* it occupies a very considerable area of the peninsula of Cornwall, constituting not less than 300,000 acres, one half of which is uninclosed waste land, affording a scanty pasturage for a miserable breed of sheep and goats; but which, by drainage and judicious cultivation, might, without doubt, be much improved. The other portion of *growan* land is endowed with various degrees of fertility and capability of improvement, in different districts, or even in different spots in the same district; a fact which seems to have an immediate connexion with the nature of the granitic substratum, and consequently to admit of elucidation from the enquiries of the geologist. That the texture of granite, and the proportion of its component parts, have a considerable influence upon the fertility of the superincumbent soil, will become evident on a bare inspection of specimens brought from fertile and barren districts. Mr. Tyacke, of Godolphin, has furnished the society with some striking specimens in confirmation of this fact, and others equally satisfactory and conclusive have been added by Mr. Giddy, the active curator of the museum. It is hardly necessary to remark, that granite consists of three substances in the state of mechanical admixture, viz. *felspar, mica,* and *quartz,* the first and last of which being essentially different in chemical composition, are necessarily so in their agricultural influence. Felspar is capable of being, in part, resolved into aluminous earth, and includes, moreover, several elements which have been discovered by experience to be highly congenial to the process of vegetation; quartz, on the contrary, has a powerful tendency to resist disintegration, and, even when it is decomposed, is reduced only into siliceous particles. The nature of felspar varies also very considerably in different kinds of granite; it occurs sometimes in an earthy form, is easily pulverized, and emits, when breathed upon, a strong smell of aluminous earth; at other times, it is met with in a hard, compact, and less earthy state, not easily yielding to the action of air and moisture. In some felspar the proportion of its siliceous greatly exceeds that of its aluminous elements, and in others, again, magnesia forms a constituent part. The relative proportion of mica appears also to have some influence, and where this ingredient occurs in considerable quantities, it is generally indicative of a poor and light soil. There are, besides, incidental ingredients in granite which must be taken into account, such, for instance, as iron, whose presence not only disposes the rock to a more rapid decomposition, but frequently becomes a useful element in the resulting soil. It would appear, then, from these views, that the value of a *growan* soil will bear a relation to the proportion of felspar in the subjacent granite; it is, therefore, a circumstance which should always be examined by the scientific agriculturist, who wishes to form a correct estimate of the capabilities of any granite district. Upon an examination of many of the more fertile parts of Cornwall, this fact is very strikingly exemplified; it will be found, that in such districts the quantity of felspar in the granite varies from 70 to 90 per cent.; and that it possesses also the earthy texture which so greatly accelerates its decomposition; this is one of the mineralogical circumstances which will explain the unusual fertility of St. Burian, Sennan, and St. Levan, near the Land's End; the lands of which are let, upon an average, at the rent of four pounds per acre. On the other hand, let the geologist, on passing over the dreary and barren moors which occupy the middle of the county, collect specimens of its granite, and they will be found to offer a striking contrast to those of more fruitful districts; many other instances might be mentioned, but the geologist will have no difficulty in multiplying them. As a general rule it may be stated, that in order to obtain the greatest fertility, the proportion of siliceous matter in a soil ought to be increased according to the quantity of rain that falls, or rather, perhaps, to the frequency of its recurrence; for it is evident, that one of the principal effects of this element is to diminish in the soil its capacity for moisture; we accordingly find, that in the rainy climate of Turin, the most prolific soil has from 77 to 80 per cent. of siliceous, and from 9 to 14 of calcareous earth; whereas in the neighbourhood of Paris, where there is much less rain, the silex bears only the proportion of from 26 to 50 *per* cent. in the most fertile districts.

" Let the agriculturist of Cornwall, then, if there be any who repine at the moisture of their climate, hail with gladness those golden showers that fill their granaries with corn, and clothe their pastures with perpetual verdure.

" We cannot contemplate this circumstance, without discovering the agency of that intelligence which Nature so constantly displays in connecting the wants and necessities of the different parts of creation with the power and means of supplying them ; thus, in primitive countries, like Cornwall, the soil necessarily requires moisture, and we perceive that the cause which occasions, at the same time supplies, this want; for the rocks elevated above the surface solicit a tribute from every passing cloud, whilst in alluvial and flat districts, where the soil is rich, deep, and retentive of moisture, the clouds float undisturbed over the plains, and the country frequently enjoys that long and uninterrupted series of dry weather which is so congenial and necessary to its fertility. Linnæus observes, that the plants which chiefly grow upon the summits of mountains are rarely found in any other situation, except in marshes; because the clouds, arrested in their progress by such elevations, keep the air in a state of perpetual moisture, somewhat resembling that of the fogs in meadows and marshes; in exemplification of this fact, the locality of *parnassia palustris* immediately suggests itself to our notice.

" The essential character of a *growan*, or granitic soil, may be stated to be a peculiar unsusceptibility to all external agents, and an inaptitude, in its internal composition, to those chemical changes with which fertility seems connected. There is rarely much soluble matter in such soils. These observations, however, apply with different degrees of force to different districts, according to the value of the soil, and to the extent of judicious improvement which it may have undergone. As a rule for the amelioration of a *growan* soil it may be recommended, as a general principle, to increase the number of its elements, and, consequently, to extend their affinities. The Cornish code of agricultural improvement, and which, indeed, may be applied to most primitive districts, is to be very shortly expressed—MIX, COMBINE, AND MULTIPLY MANURES.—In the treatment of a siliceous soil, in particular, the manures cannot be too complicated; and those of an animal and vegetable nature should be always previously mixed with clay, decomposing slate, or other argillaceous matter, with which they may contract an intimate union, and by such means be more securely preserved in the land to which they are applied. Mr. Scobell, of Nancealverne, near the Land's End, communicated to the author a singular practice which the farmers in his neighbourhood pursued with evident advantage, that of actually dressing their sterile lands with the comminuted fragments of decomposing granite. Strange and problematical as such a practice may appear to the agriculturist, who has not studied the subject of mineral manures, to the chemist it is a fact of easy and satisfactory explanation; the decomposing granite contains, as before stated, large quantities of felspar, and therefore of alumina, with, perhaps, small quantities of alkali. Upon the same principle the application of decomposing *clay-slate* proves a valuable manure for siliceous lands, since it contains alumina in great quantities, and is therefore capable of imparting to them that tenacity of which such soils are destitute.

"The intermixture of soils, or of decomposing rocks capable of producing them, where one kind of earth is either redundant or deficient, has been most successfully practised in other counties. Mr. Bakewell, in his introduction to Geology, observes, that part of Lancashire is situated on the *red sand rock*, which being principally composed of siliceous earth and the oxide of iron, forms of itself very unproductive land; but that, fortunately, in many situations, it contains detached beds of calcareous marle, by the application of which it is converted into a most fertile soil. Mr. Brande has also remarked, that experience and science have greatly improved the advantages to be derived from the proximity of different soils to each other, and that there can be no better illustration of the utility of an intimate acquaintance with the relation of the different strata, than the amelioration of the Suffolk sands, which, by the proper application of a substratum of a shelly marle, provincially termed *crag*, have been changed from a parched and useless heath to arable and productive land.

"A most interesting illustration of the above views seems to be presented in an extraordinary fact lately discovered in the county of Cornwall, respecting the increased fertility which characterises soils that are superincumbent upon the junctions of rocks. The most superficial observer may easily satisfy himself of the truth of this fact; indeed the line of junction between the granite and slate formations may, in many parts, be traced by the eye alone through tracts of cultivation, from the remarkable fertility which attends it. It may be defined a *zone of fertility*, since both the growan and slaty soils become mutually enriched as they approach each other: Numerous are the examples which might be adduced in confirmation of this fact; the following, as being accessible to investigation, are here particularised. The most valuable part of the estate of Trengwainton, the seat of Sir Rose Price, Bart., lies upon a junction of slate and granite; this line may be traced to Madron church, and from thence round the Mount's Bay, in the direction of which we shall invariably find the superincumbent soil distinguished for its superior fruitfulness. It is, perhaps, worth notice, that all the villas around this beautiful bay are placed upon the junction of rocks. Where the *hornblende formation* intrudes itself, the fertility of the land is still farther increased, as may be seen on the valuable estates of Castle Horneck and Trereiffe. The zone of fertility may be also seen well characterised on the line of junction between granite and slate at Penrhyn, and on that extending from Chyoon on the acclivity of Paul Hill, to Mousehole, in the Mount's Bay; this latter instance attracted the attention of Mr. Worgan, who, in his general view of the agriculture of Cornwall, notices this district as one highly fertile, and as being famous for producing two crops of potatoes in one year. On Saint Michael's Mount, that 'precious stone, set in the silver sea,' the geologist will also discover a good example of the fertilizing influence which the junction of slate and granite exerts upon the superincumbent soil; the beautiful carpet of herbage covering the south-eastern base of the singular spot is a feature which instantly strikes the attention of the stranger."

## NOTE 19. p. 136.

The geological researches of Doctor Buckland have been long directed by a desire to accumulate facts to prove that there must have been an universal inundation of the earth; and, in his inaugural lecture, he has presented us with a summary of such facts, which, to use his own expression, whether considered collectively or separately, present such a conformity of proofs, tending to establish the universality of a recent inundation of the earth, as no difficulties or objections that have hitherto arisen, are in any way sufficient to overrule. The facts are as follow.

"I. The general shape and position of hills and valleys; the former having their sides and surfaces universally modified by the action of violent waters, and presenting often the same alternation of salient and retiring angles, that mark the course of a common river; and the latter, in those cases which are called valleys of denudation, being attended with such phenomena, as show them to owe their existence entirely to excavation, under the action of a flood of waters.

"II. The almost universal confluence and successive inosculations of minor valleys with each other, and final termination of them all in some main trunk, which conducts their waters to the sea; and the rare interruption of their courses by transverse barriers producing lakes.

"III. The occurrence of detached insulated masses of horizontal strata called *outliers*, at considerable distances from the beds of which they once evidently formed a continuous part, and from which they have been separated at a recent period, by deep and precipitous valleys of denudation.

"IV. The immense deposits of gravel that occur occasionally on the summit and slopes of hills, and almost universally in valleys over the whole world; in situations to which no torrents or rivers that are now in action could ever have drifted them.

"V. The nature of this gravel, being in part composed of the wreck of the neighbouring hills, and partly of fragments and blocks that have been transported from very distant regions.

"VI. The nature and condition of the organic remains peculiar to this gravel; many of them being identical with, and others not distinguished from, species that now exist, and very few having undergone the smallest process of mineralization. Their condition resembles that of common grave bones, being in so recent a state, and having undergone so little decay, that if the records of history, and the circumstances that attend them, did not absolutely forbid such a supposition, we should be inclined to attribute them even to a much later period than the deluge; and certainly there is not a single fact connected with them, that should lead us to date their origin from any more ancient era.

"VII. The total impossibility of referring any one of these appearances to the effect of ancient or modern rivers, or any other causes, that are now, or appear ever to have been, in action, since the retreat of the diluvian waters.

"VIII. The analogous occurrence of similar phænomena in almost all the regions of the world that have hitherto been scientifically investigated, presenting a series of facts that are uniformly consistent with the hypothesis of a contemporaneous and diluvial origin.

"IX. The perfect harmony and consistency in the circumstances of those few changes that now go on (*e. g.* the formation of ravines and gravel by mountain torrents; the limited depth and continual growth of peat bogs, the formation of tufa, sand-banks, deltas, coral reefs, and streams of lava; and the filling up of lakes, estuaries, and marshes,) with the hypothesis which dates the commencement of all such operations, at a period not more ancient than that which our received chronologies assign to the deluge."

In the collection and arrangement of the foregoing facts, we discern the operations of a mind laborious in research; and so logically constituted as to be enabled to separate the strong proofs from the weaker and less important matter with which they are mixed up; but we have now to view the labours of Dr. Buckland in a very different light; we have to regard him no longer as the able reasoner upon known phænomena, but as the original discoverer of new facts, highly important in their inferences, and calculated to furnish additional support to the theory, of which he is so powerful an advocate.

In the year 1822, Dr. Buckland read a memoir before the Royal Society, announcing the discovery of a singular cave at Kirkdale in Yorkshire, containing an assemblage of fossil teeth and bones of the elephant, rhinoceros, hippopotamus, bear, tiger, and hyæna, and sixteen other animals; with a comparative view of five similar caverns in various parts of England, and others on the continent. For this important paper the society awarded to its author their Copley medal; and it constitutes the basis of a later and much more extended work, entitled "RELIQUIÆ DILUVIANÆ; or Observations on the Organic Remains contained in Caves, Fissures, and Diluvial Gravel; and on other Geological Phenomena, attesting the Action of an Universal Deluge. By the Rev. W. BUCKLAND, B.D. F.R.S. &c."

Kirkdale is situated about 25 miles N. N. E. of the city of York, between Helmsley and Kirby Moorside, near the point at which the east base of the Hambleton hills, looking towards Scarborough, subsides into the vale of Pickering, and on the south extremity of the mountainous district known by the name of the Eastern and Cleveland moorlands.

The substratum of this valley is a mass of stratified clay, identical with that which at Oxford and Weymouth reposes on a similar limestone to that of Kirkdale, and containing, subordinately, beds of inflammable bituminous shale, like that of Kimeridge in Dorsetshire. Its south boundary is formed by the Howardean hills, and by the elevated escarpment of the chalk, that terminates the Wolds towards Scarborough. Its north frontier is composed of a belt of limestone, extending eastward 30 miles from the Hambleton hills, near Helmsley, to the sea at Scarborough, and varying in breadth from four to seven miles; this limestone is intersected by a succession of deep and parallel valleys (called *dales*,) through which the following rivers from the moorlands pass down southwards the vale of Pickering, viz. the Rye, the Rical, the Hodge Beck, the Dove, the Seven Beck, and the Costa; their united streams fall into the Derwent above New Malton, and their only outlet is by a deep gorge, extending from near this town down to Kirkham, the stoppage of which would at once convert the whole vale of Pickering into an immense inland lake; and before the excavation of which, it is probable that such a lake existed, having its north border nearly along the edge of the belt of limestone just described, and at no great distance from the mouth of the cave at Kirkdale.

The position of the cave is at the south and lower extremity of one of these dales (that of the Hodge Beck,) at the point where it falls into the vale of Pickering. It occurs in that species of limestone rock which is usually perforated by irregular holes and caverns intersecting them in all directions. The abundance of such cavities in the limestone of the vicinity of Kirkdale is evident from the fact of the engulfment of several of the rivers above enumerated, in the course of their passage across it; and it is important to observe, that the elevation of the Kirkdale cave above the bed of the Hodge Beck, being nearly 80 feet, excludes the possibility of our attributing the muddy sediment we shall find it to contain to any land flood, or extraordinary rise of the waters of this, or of any other river in the neighbourhood.

But let us explore the interior of this cavern. It was not till the summer of 1821, that the existence of any animal remains, or of the cavern containing them, was suspected. At this time, in continuing the operations of a large quarry, the workmen accidentally intersected the mouth of a long hole, closed externally with rubbish, and overgrown with grass and bushes. As this rubbish was removed before any competent person had examined it, it is not certain whether it was composed of diluvial gravel and rolled pebbles, or was simply the debris that had fallen from the softer portions of the strata that lay above it; the workman, however, who removed it, and some gentlemen who saw it, assured Dr. Buckland that it was composed of gravel and sand. In the interior of the cavern, our indefatigable geologist could not find a single rolled pebble, nor has he ever seen one bone, or fragment of bone, that bore the slightest mark of having been rolled by the action of water.

The original entrance is said to have been very small, and having been filled up as above described, there could not have been any admission of external air through it to the interior of the cavern. Nearly 30 feet of its outer extremity have now been removed, and the present entrance is a hole in the perpendicular face of the quarry, about three feet high and five feet broad, which it is only possible for a man to enter on his hands and knees, and which expands and contracts itself irregularly from two to seven feet in breadth, and two to fourteen feet in height. It is unnecessary to enter into farther details; the reader, if he wishes more minute information, may consult Dr. Buckland's work.

On entering the cave, the first thing observed was a sediment of soft mud or loam, covering entirely its whole bottom to the average depth of about a foot, and concealing the subjacent rock, or actual floor of the cavern. Not a particle of mud was found attached either to the sides or roof; nor was there a trace of it adhering to the sides or upper portions of the transverse fissures, or any thing to suggest the idea that it had entered through them. The mud was covered by a *stalagmytic* crust, which had been formed by the dripping of water impregnated with calcareous matter, as is common in all the cavities of limestone; but it is important to remark, that there was not any alternation of mud with any repeated beds of *stalagmyte*, but simply a partial deposit of the latter on the floor beneath; so that the mud was encased, like meat in a pie, with an upper and under crust. It was chiefly in the lower part of the earthy sediment, and in the calcareous matter beneath it, that the animal remains were found.

In the whole extent of the cave, only a very few large bones have been discovered that are tolerably perfect; most of them are broken into small angular fragments and chips, the greater part of which lay separately in the mud, whilst others were wholly or partially invested with stalagmite, and others again mixed with masses of still smaller fragments. In some few places, where the mud was shallow, and the heaps of teeth and bones considerable, parts of the latter were elevated some inches above the surface of the mud and its calcareous crust; and the upper ends of the bones thus projecting, like the legs of pigeons through a pie crust, into the void space above, have become thinly covered with calcareous drippings, whilst their lower extremities have no such incrustation, and have simply adhering to them the mud in which they have been imbedded.

The effect of the loam and stalagmite in preserving the bones from decomposition, by protecting them from all access of atmospheric air, has been very remarkable.

The workmen, in first discovering the bones at Kirkdale, supposed them to have belonged to cattle that died by a murrain in this district a few years ago, and they were for some time neglected, and thrown on the roads with the common limestone; they were, at length, noticed by Mr. Harrison, a medical gentleman in the neighbourhood, and have since been collected and deposited in various private and public museums. The teeth and bones which have been discovered in this cave appear to have belonged to the *hyæna, tiger, bear, wolf, fox, weasel, elephant, rhinoceros, hippopotamus, horse, ox, deer, hare, rabbit, water-rat, mouse, raven, pigeon, lark, snipe,* and a small species of *duck.*

The bottom of the cave, on first removing the mud, was found to be strewed all over like a dog-kennel, from one end to the other, with hundreds of teeth and bones, or rather broken and splintered fragments of bones, of all the animals above enumerated; scarcely a single bone has escaped fracture, with the exception of some of the more solid and hard bones of the foot; on some of these bones, marks may be traced, which, on applying one to the other, appear exactly to fit the form of the canine teeth of the hyæna that occur in the cave. The hyæna's bones have been broken, and apparently gnawed equally with those of the other animals. Heaps of small splinters, and highly comminuted, yet angular fragments of bone, mixed with teeth of all the varieties of animals above enumerated, lay in the bottom of the den, occasionally adhering together by calcareous cement. Not one skull is to be found entire; and it is so rare to find a large bone of any kind that has not been more or less broken, that there is no hope of obtaining materials for the construction of a single limb, and still less of an entire skeleton. The jaw-bones, also, even of the hyænas, are broken to pieces like the rest.

It must already appear probable, from the facts above described, particularly from the comminuted and gnawed condition of the bones, that the cave at Kirkdale was, during a long succession of years, inhabited as a den by hyænas, and that they dragged into its recesses the other animals, whose remains are found indiscriminately mixed with their own; an hypothesis which is certainly strengthened by Dr. Buckland having found the excrement of the animal in the same cave. Should it be asked why we do not find, at least, the entire skeleton of the one or more hyænas that died last, and left no survivors to devour them; we find a sufficient reply to this question, in the circumstance of the probable destruction of the last individuals by the waters of the deluge. On the rise of these, had there been any hyænas in the den, they would have rushed out, and fled for safety to the hills; and if absent, they could not by any possibility have returned to it from the higher levels; that they were extirpated by the catastrophe is obvious, from the discovery of their bones in the diluvial gravel both of England and Germany.

The accumulation of these bones, then, appears to have been a process of years, whilst all the animals in question were natives of this country. The general dispersion of bones of the same animals through the diluvian gravel of high latitudes, over a great part of the northern hemisphere, shows that the period in which they inhabited these regions was that immediately preceding the formation of this gravel, and that they perished by the same waters which produced it. M. Cuvier has, moreover, ascertained that the fossil elephant, rhinoceros, hippopotamus, and hyæna, belong to species now unknown; and as there is no evidence that they have at any time, subsequent to the formation of the diluvium, existed in these regions, we may conclude that the period, at which the bones of these extinct species were introduced into the cave at Kirkdale was before the deluge.

Thus the phenomena of this cave seem referable to a period immediately antecedent to the general deluge, and in which the world was inhabited by land animals, almost all bearing a generic, and many a specific resemblance to those which now exist; but so completely has the violence of that tremendous convulsion destroyed and remodelled the form of the antediluvian surface, that it is only in caverns that have been protected from its ravages, that we may hope to find undisturbed evidence of events in the period immediately preceding it. The bones already described, and the calcareous matter formed before the introduction of the diluvial mud, are what Dr. Buckland considers to be the products of the period in question. It was indeed probable, before the discovery of this cave, from the abundance in which the remains of similar species occur in superficial gravel beds, which cannot be referred to any other than a diluvial origin, that such animals were the antediluvian inhabitants not only of this country, but generally of all those northern latitudes in which their remains are found (but the proof was imperfect, as it was possible they might have been drifted or floated hither by the waters from the warmer regions of the earth), but the facts developed in this charnel-house of the antediluvian forests of Yorkshire, demonstrate that there was a long succession of years, in which the elephant, rhinoceros, and hippopotamus, had been the prey of the hyænas, which, like themselves, inhabited England in the period immediately preceding the formation of the diluvial gravel. Having thus far described the principal facts to be observed in the interior of this cave, Dr. Buckland proceeds to point out the chronological inferences that may be derived from the state of the bones, and of the mud and stalagmite that accompany them, and to extract the following detail of events that have been going on successively within this curious cave:—

First, There appears to have been a period (and, if we may form an estimate from the small quantity of stalagmite now found on the actual floor of the cave, a very short one), during which this aperture in the rock existed in its present state, but was not tenanted by the hyænas.

The second period was that during which the cave was inhabited by the hyænas, and the stalactite and stalagmite were still forming.

The third period is that at which the mud was introduced and the animals extirpated, viz. the period of the deluge. It has been already stated, that there is not any alternation of this mud with beds of bone or of stalagmite, such as would have occurred had it been produced by land floods often repeated; *once, and once only*, it appears to have been introduced; and we may consider its vehicle to have been the turbid waters of the same inundation that produced universally the diluvial gravel.

The fourth period is that during which the stalagmite was deposited which invests the upper surface of the mud.

We have attempted, in this note, to give a slight sketch of the history of this curious cavern, and of the important inferences to be deduced from its phenomena; rather with the hope of inducing the reader to peruse the interesting volume of Dr. Buckland, from which these extracts have been made, than of affording a full and satisfactory account of a discovery which has, at once, redeemed geology from the charge of fabricating theories inconsistent with divine revelation.

## NOTE 20. p. 138.

Rifle guns are those whose barrels, instead of being smooth on the inside, like our common pieces, are formed with a number of spiral channels, resembling screws; except only that the threads, or rifles, are less deflected, making only one turn, or a little more, in the whole length of the piece. This construction is employed for correcting the irregularity in the flight of balls, from smooth barrels, by imparting to the balls a rotatory motion perpendicular to the line of direction. The same effect has lately been accomplished by an extremely simple and obvious contrivance, and which will, probably, altogether supersede the necessity of rifling the barrel. It consists in cutting a spiral groove in the bullet itself, which, when discharged, is thus acted upon by the air, and the same rotatory motion imparted to it as that produced by the furrows in the barrel. But it is the rotatory motion which steadies the flight of the ball; and by whichever method this is produced, the theory of its action will be the same. It has been long and generally known, that when the common bullet is discharged from a plane barrel, its flight is extremely irregular and uncertain; it has, for instance, been found, from the experiments of Mr. Robins, that notwithstanding the piece was firmly fixed, and fired with the same weight of powder, the ball was sometimes deflected to the right, sometimes to the left, sometimes above, and at others below the true line of direction. It has also been observed, that the degree of deflection increases in a much greater proportion than the distance of the object fired at. It is not difficult to account for these irregularities; they, doubtless, proceed from the impossibility of fitting a ball so accurately to any plane piece, but that it will rub more against one side of the barrel than another, in its passage through it. Whatever side, therefore, of the muzzle, the ball is last in contact with, on quitting the piece, it will acquire a whirling motion towards that side, and will be found to bend the line of its flight in the same direction, whether it be upwards or downwards, to the right or left; or obliquely, partaking, in some degree of both; and after quitting the barrel, this deflection, though in the first instance but trifling and inconsiderable, is still farther increased by the resistance of the air; this being greatest on that side where the whirling motion conspires with the progressive one, and least on that side where it is opposed to it. Thus, if the ball, in its passage out, rubs against the left side of the barrel, it will whirl towards that side; and as the right side of the ball will, therefore, turn up against the air during its flight, the resistance of the air will become greatest on the right side, and the ball be forced away to the left, which was the direction it whirled in. It happens, moreover, from various accidental circumstances, that the axis of the ball's rotation frequently changes its position several times during the flight; so that the ball, instead of bending its course uniformly in the same direction, often describes a track variously contorted. From this view of the causes of aberration in the flight of balls, it will be evident, that the only means of correcting it is by preventing the ball from rubbing more against one side of the barrel than another in passing through it; and by giving to the bullet a motion which will counteract every accidental one, and preserve its direction, by making the resistance of the air upon the forepart continue the same during its whole flight; that is, by giving it a rotatory motion perpendicular to the line of direction. The contrivance for this purpose is called *rifling*, and consists, as we have before stated, in forming upon the inside of the barrel a number of threads and furrows, either in a straight or spiral direction, into which the ball is moulded; and hence, when the gun is fired, the indented zone of the bullet follows the sweep of the rifle, and thereby, besides its progressive motion, acquires a considerable one round the axis of the barrel, which motion will be continued to the bullet after its separation from the piece, so that it is constantly made to whirl round an axis coincident with the line of its flight.

### NOTE 21. p. 145.

If a stick be held at one of its extremities and allowed to fall on the edge of a table, the farther end will rebound, or the hand will sustain a shock, unless it be struck exactly on the centre of percussion, in which case the stick will fall as a dead weight. The repetition of this simple experiment will readily convey to the young philosopher an idea of the nature of what is termed the *centre of percussion.*

### NOTE 22. p. 152.

It has been stated in the text, that the gyrations of the top depend exactly upon the same principle as that which produces the *precession of the equinoxes;* viz. an unequal attractive force exerted upon the revolving mass. In the one case, this is known to arise from the action of the sun and moon on the excess of matter about the equatorial regions of the earth; in the other, from the parts of the top being unequally affected by gravity, while it is spinning in an inclined or oblique position. To those philosophers who have condescended to read the present work, if there be any such, and are thereby induced to pursue the investigation of a subject which has hitherto excited far too little attention, we beg to submit the following remarks:—

If a top could be made to revolve on a point without friction, and in a vacuum, in the case of its velocity being *infinite*, it would continue to revolve for ever, in the same position, without gyration. If the velocity were *finite*, it would for ever remain unchanged in position, in the event of the centre of gravity being directly over the point of rotation. In any other position (supposing its velocity very great, although not infinite) there would arise a continued uniform gyration. The line which passes through the point of rotation, and the centre of gravity, always making the same angle with the horizon, or describing the same circle round the zenith. But in all artificial experiments the circumstances are very remarkably changed; if, indeed, the centre of gravity happens to be situated perpendicularly over the point of rotation, the top will continue quite steady, or *sleeping*, as it is termed, till nearly the whole of its velocity of rotation is expended. In any other position the top begins to gyrate, but reclining at all times on the outside of its physical point of gyration, the top is uniformly impelled inwards, and this (when the velocity is considerable, and the point broad) acts with a force sufficient for carrying the top towards its quiescent or *sleeping* point; but when the velocity is much diminished, this power becomes feeble, the gyrations increase in diameter, and the top ultimately falls.

## NOTE 23. p. 164.

The mechanical powers are all founded upon the principle that *the lengths of circles are in proportion to their diameters:* for it is an immediate consequence of this property of the circle, that if a rod of iron, or beam of wood, be placed on a point or pivot, so that it may move round its prop, the two ends will go through parts of circles, each proportioned to that arm of the beam to which it belongs; the two circles will be equal if the pivot is in the centre or middle point of the beam; but if it is nearer one end than the other, say five times, that end will pass through a circular space, or *arc*, five times shorter than the circular space the other end goes through in the same time. If, then, the end of the long beam goes through five times the space, it must move with five times the swiftness of the short end, since both move in the same time; and, therefore, any force applied to the long end must overcome the resistance of five times that force applied at the opposite end, since the two ends move in contrary directions; hence one pound placed at the long end would balance five placed at the short end.

The beam we have been describing constitutes the first of the mechanical powers, and is termed the LEVER. There are, besides, five others, viz. the *wheel and axle*; the *inclined plane*; the *screw*; the *pulley*; and the *wedge*; out of the whole, or a part of which, it will be found that every mechanical engine or piece of machinery is constructed.

THE LEVER being the simplest of all the mechanic powers, is in general considered the first. It is an inflexible rod or bar of any kind, so disposed as to turn on a pivot or prop, which is always called its *fulcrum*. It has the weight or resistance to be overcome attached to some one part of its length, and the power which is to overcome that resistance applied to another; and, since the *power*, *resistance*, and *fulcrum* admit of various positions with regard to each other, so is the lever divided into three kinds or modifications, distinguished as the first, second, and third kinds of lever. That portion of it which is contained between the fulcrum and the power, is called the acting part or arm of the lever; and that part which is between the fulcrum and resistance, its resisting part or arm.

In the lever of the first kind, the fulcrum is placed between the power and the resistance. A poker, in the act of stirring the fire, well illustrates this subject; the bar is the *fulcrum*, the hand the power, and the coals the resistance to be overcome. Another common application of this kind of lever is the crow-bar, or hand-spike, used for raising a large stone or weight. In all these cases, power is gained in proportion as the distance from the fulcrum to the power, or part where the men apply their strength, is greater than the distance from the fulcrum to that end under the stone or weight. A moment's reflection will show the rationale of this fact; for it is evident that if both the arms of the lever be equal, that is to say, if the fulcrum be midway between the power and weight, no advantage can be gained by it, because they pass over equal spaces in the same time;

and, according to the fundamental principle already laid down, *as advantage or power is gained, time must be lost;* but, since no time is lost under such circumstances, there cannot be any power gained. If now, we suppose the fulcrum to be so removed towards the weight, as to make the acting arm of the lever three times the length of the resisting arm, we shall obtain a lever which gains power in the proportion of three to one, that is, a single pound-weight applied at the upper end will balance three pounds suspended at the other. A pair of scissors consists of two levers of this kind, united in one common fulcrum; thus the point at which the two levers are screwed together is the fulcrum; the handles to which the power of the fingers is applied, are the extremities of the acting part of the levers, and the cutting part of the scissors are the resisting parts of the levers; the longer, therefore, the handles, and the shorter the points of the scissors, the more easily you cut with them. A person who has any hard substance to cut, without any knowledge of the theory, diminishes as much as possible the length of the resisting arms, or cutting part of the scissors, by making use of that part of the instrument nearest the screw or rivet. Snuffers are levers of a similar description; so are most kind of pincers, the power of which consists in the resisting arm being very short in comparison with the acting one.

In the lever of the second kind, the resistance or weight is between the fulcrum and the power. Numberless instances of its application daily present themselves to our notice; amongst which may be enumerated the common cutting knife, used by last and patten makers, one end of which is fixed to the work-bench by a swivel-hook. Two men carrying a load between them, by one or more poles, as a sedan chair, or as brewers carrying a cask of beer, in which case either the back or front man may be considered as the fulcrum, and the other as the power. Every door which turns upon its hinges is a lever of this kind; the hinges may be considered as the fulcrum, or centre of motion, the whole door is the weight to be moved, and the power is applied to that side on which the handle is usually fixed. Nut-crackers, oars, rudders of ships, likewise fall under the same division. The boat is the weight to be moved, the water is the fulcrum, and the waterman at the oar is the power. The masts of ships are also levers of the second kind, for the bottom of the vessel is the fulcrum, the ship the weight, and the wind acting against the sail is the moving power. In this kind of lever the power or advantage is gained in proportion as the distance of the power is greater than the distance of the weight from the fulcrum; if, for instance, the weight hang at one inch from the fulcrum, and the power acts at five inches from it, the power gained is five to one; because, in such a case, the power passes over five times as great a space as the weight. It is thus evident why there is considerable difficulty in pushing open a heavy door, if the hand is applied to the part next the hinges, although it may be opened with the greatest ease in the usual method. In the third kind of lever, the fulcrum is again at one of the extremities, the weight or resistance at the other; and it is now the power which is applied between the fulcrum and resistance. As in this case the weight is farther from the centre of motion than the power, such a lever is never used, except in cases of absolute necessity, as in the case of lifting up a ladder perpendicularly, in order to place it against a wall. The man who raises it cannot place his hands on the upper part of the ladder; the power, therefore, is necessarily placed much nearer the fulcrum than the weight; for the hands are the power, the ground the fulcrum, and the upper part of the ladder the weight. The use of the common fire-tongs is another example, but the circumstance that principally gives this lever importance is, that the limbs of men and animals are actuated by it; for the bones are the levers, while the joints are the fulcra, and the muscles which give motion to the limbs, or produce the power, are inserted and act close to the joints, while the action is produced at the extremities; the consequence of such an arrangement is, that although the muscles must necessarily exert an enormous contractile force to produce great action at the extremities, yet a celerity of motion ensues which could not be equally well provided for in any other manner. We may adduce one example in illustration of this fact. In lifting a weight with the hand, the lower part of the arm becomes a lever of the third kind; the elbow is the fulcrum; the muscles of the fleshy part of the arm the power; and as these are nearer to the elbow than the hand, it is necessary that their power should exceed the weight to be raised. The disadvantage, however, with respect to power, is more than compensated by the convenience resulting from this structure of the arm; and it is no doubt that which is best adapted to enable it to perform its various functions. From these observations it must appear, that although this arrangement must be mentioned as a modification of the lever, it cannot, in strictness, be called a mechanical power; since its resisting arm is in all cases, except one, longer than the acting arm, and in that one case is equal to it, on which account it never can gain power, but in most instances must lose it.

THE WHEEL AND AXLE is the next mechanical power to be considered; it must be well known to every reader who has seen a village well; for it is by this power that the bucket is drawn up, although in such cases, instead of a wheel attached to the axle, there is generally only a crooked handle, which answers the purpose of winding the rope round the axle, and thus raising the bucket, as may be seen in the engraving at the head of our third chapter. It is evident, however, that this crooked handle is equivalent to a wheel; for the handle describes a circle as it revolves, while the straight piece which is united to the axle corresponds with the spoke of a wheel. This power may be resolved into a lever; in fact, what is it but a lever moving round an axle? and always retaining the effect gained during every part of the motion, by means of a rope wound round the butt end of the axle; the spoke of the wheel being the long arm of the lever, and the half diameter of the axle its short arm. The axle is not in itself a mechanical power, for it is as impotent as a lever, whose fulcrum is in the centre; but add to it the wheel, and we have a power which will increase in proportion as the circumference of the wheel exceeds that of the axle. This arises from the velocity of the circumference being so much greater than that of the axle, as it is farther from the centre of motion; for the wheel describes a great circle in the same space of time that the axle describes a small one; therefore the power is increased in the same proportion as the circumference of the wheel is greater than that of the axle. Those who have ever drawn a bucket from a well by this machine, must have observed, that as the bucket ascended nearer the top the difficulty increased: such an effect must necessarily follow from the views we have just offered; for whenever the rope coils more than once the length of the axle, the difference between its circumference and that of the wheel is necessarily diminished. To the principle of the wheel and axle may be referred the capstan, windlass, and all those numerous kinds of cranes which are to be seen at the different wharfs on the banks of the river Thames. It is scarcely necessary to add, that the force of the wind-mill depends upon a similar power. The *tread-mill* furnishes another striking example. The wheel and axle is sometimes used to multiply motion, instead of to gain power, as in the multiplying wheel of the common jack, to which it is applied when the weight cannot conveniently have a long line of descent; a heavy weight is in this case made to act upon the axle, while the wheel, by its greatest circumference, winds up a much longer quantity of line than the simple descent of the weight could require, and thus the machine is made to go much longer without winding than it otherwise would do.

THE PULLEY is a power of very extensive application. Every one must have seen a pulley; it is a circular and flat piece of wood or metal, with a string which runs in a groove round it. Where, however, this is fixed, it cannot afford any power to raise a weight; for it is evident, that, in order to raise it, the power must be greater than the weight, and that if the rope be pulled down one inch, the weight will only ascend the same space; consequently, there cannot be any mechanical advantage from the arrangement. This, however, is not the case, where the pulley is not fixed. Suppose one end of the rope be fastened to a hook in the ceiling, and that to the moveable pulley on the rope a cask be attached, is it not evident that the hand applied to the other extremity of the rope will sustain it more easily than if it held the cask suspended to a cord without a pulley? Experience shows that this is the fact, and theory explains it by suggesting that the fixed hook sustains half the weight, and that the hand, therefore, has only the other half to sustain. The hook will also afford the same asssistance in raising the weight as in sustaining it; if the hand has but one half the weight to sustain, it will also have only one half the weight to raise; but observe, says Mrs. Marcet, that in raising the weight, the velocity of the hand must be double that of the cask; for in order to raise the weight one inch the hand must draw each of the strings one inch; the whole string is therefore shortened two inches, while the weight is raised only one. Pulleys then act on the same principle as the lever, the deficiency of strength of the power being compensated by its superior velocity. It will follow, from these premises, that the greater the number of pulleys connected by a string, the more easily the weight is raised, as the difficulty is divided amongst the number of strings, or rather of parts into which the string is divided by the pulleys. Several pulleys, thus connected, form what is called a system, or tackle of pulleys. They may have been seen suspended from cranes, to raise goods into warehouses, and in ships to draw up the sails.

THE INCLINED PLANE is a mechanic power which is seldom used in the construction of machinery, but applies more particularly to the moving or raising of loads upon slopes or hills, as in rolling a cask up or down a sloping plank into or out of a cart or cellar, or drawing a carriage up a sloping road or hill, all which operations are performed with less exertion than would be required if the same load were lifted perpendicularly. It is a power which cannot be resolved into that of the lever; it is a distinct principle, and those writers who have attempted to simplify the mechanical powers, have been obliged to acknowledge the inclined plane as elementary. The method of estimating the advantage gained by this mechanical power is very easy; for just as much as the length of the plane exceeds its perpendicular height, so much is the advantage gained; if, for instance, its length be three times greater than its height, a weight could be drawn to its summit with a third part of the strength required for lifting it up at the end; but, in accordance with the principle so frequently alluded to, such a power will be at the expense of time, for there will be three times more space to pass over. The reason why horses are eased by taking a zigzag direction, in ascending or descending a steep hill, will appear from the preceding account of the action of the inclined plane, because in this way the effective length of the inclining surface is increased while its height remains the same.

THE WEDGE is rather a compound, than a distinct mechanical power; since it is composed of two inclined planes, and in action frequently performs the functions of a lever. It is sometimes employed in raising bodies, thus the largest ship may be raised to a small height by driving a wedge below it; but its more common application is that of dividing and cleaving bodies. As an elevator, it resembles exactly the inclined plane; for the action is obviously the very same, whether the wedge be pushed under the load, or the load be drawn over the wedge. But when the wedge is drawn forward, the percussive tremor excited destroys, for an instant, the adhesion or friction at its sides, and augments prodigiously the effect. From this principle chiefly is derived the power of the wedge in rending wood and other substances. It then acts besides as a lever, insinuating itself into the cleft as fast as the parts are opened by the vibrating concussion. To bring the action of the wedge, therefore, under a strict calculation, would be extremely difficult, if not impossible. Its effects are chiefly discovered by experience. All the various kinds of cutting tools, such as axes, knives, chisels, saws, planes, and files, are only different modifications of the wedge.

THE SCREW is a most efficient mechanic power, and is of great force and general application. It is in reality nothing more than an inclined plane formed round a cylinder, instead of being a continued straight line. Its power is, therefore, estimated by taking its circumference, and dividing this by the distance between any two of its threads; for what is taking the circumference of a screw, but another mode of measuring the length of the inclined plane which wraps round it? and taking the distance between one thread and the next to it, is but measuring the rise of that inclined plane in such length; and from the properties of the inclined plane, it follows, that the closer the threads of a screw are together, in proportion to its diameter, the greater will be the power gained by it.

## NOTE 24. p. 168.

A *cycloid* is a peculiar curve line; and is described by any one point of a circle as it rolls along a plane, and turns round its centre; thus, for instance, the nail on the felly of a cart-wheel traces a cycloid in the air as the wheel proceeds. This curve is distinguished by some remarkable properties, the most important of which is, that mentioned in the text, viz. that any body moving in such a curve, by its own weight, or swing, will pass through all distances of it in exactly the same time; and it is for such a reason that pendulums are made to swing in cycloids, in order that they may move in equal times, whether they go through a long or a short part of the same curve. Where the arc described is small, a portion of the circle will be sufficiently accurate, because it will be seen that such an arc will not deviate much from an equal portion of a cycloidal curve.

The cycloid is remarkable as being that path, with the exception of the perpendicular, through which a body will move with the greatest velocity; suppose, for example, a body is to descend from any one point to any other, by means of some force acting on it, together with its weight: a person unacquainted with mechanics would say at once, that a straight line is the path it must take to effect this in the shortest possible time, since that is the shortest of all lines that can be drawn between two points. Undoubtedly it is the shortest; notwithstanding which, however, the body would be longer in traversing it, than in moving through a cycloid. If a body were to move through a space of fifty or a hundred yards, by its weight and some other force acting together, the way it must take to do this, in the shortest possible time, is by moving in a cycloid. It is supposed that birds which build in the rocks possess an instinctive knowledge of this fact, and drop or fly down from height to height in this course. There is certainly a general resemblance between the curved path they describe on such occasions, and the cycloid, but it would be difficult to establish the fact by experiment. Man, however, has founded upon this principle some applications of great value in practical mechanics. In Switzerland, and in several parts of Germany, for example, slides have been constructed along the sides of mountains, by which the timber felled near their summits is conducted with extreme rapidity to the distant valleys.

## NOTE 25. p. 174.

In investigating the effects produced upon bodies by collision, it is necessary to distinguish between elastic and non-elastic substances, since their motions after impact are governed by very different laws.

If two bodies, *void of elasticity*, move in one right line, either the same or contrary ways, so that one body may strike directly against another, let the *sum* of their motions before the stroke, if they move the same way, and the *difference* of their motions, if contrary ways, be divided into two such parts as are proportional to the quantities of matter in the bodies, and each of those parts will respectively exhibit the motion of each body after the stroke: for example, if the quantities of matter in the bodies be as *two* to *one*, and their motions before the stroke as *five* and *four*, then the sum of their motions is *nine*, and the difference is *one*; and therefore, when they move the same way, the motion of that body, which is as *two*, will, after the stroke, be *six*, and the motion of the other, *three*; but, if they move in contrary directions, the motion of the greater body after the stroke will be *two thirds of one*, and of the lesser body *one third of one*; for, since the bodies are void of elasticity, they will not separate after the stroke, but move together with one and the same velocity; and, consequently, their motions will be proportional to their quantities of matter; and it follows from the fact of action and reaction being equal, that no motion is either lost or gained by the stroke when the bodies move the same way; because, whatever motion one body imparts to the other, so much must it lose of its own; and, consequently, the *sum* of their motions before the stroke is neither increased nor diminished by the stroke, but is so divided between the bodies, as that they may move together with one common velocity; that is, it is divided between the bodies in proportion to their quantities of matter: but it is otherwise, where the bodies move in opposite directions, or contrary ways, for then the smaller motion will be destroyed by the stroke, as also an equal quantity of the greater motion, because action and reaction are equal; and the bodies, after the stroke, will move together equally swift, with the *difference* only of their motions before the stroke; consequently, that difference is, by means of the stroke, divided between them in proportion to their quantities of matter.

The several particular cases, concerning the collision of bodies, may be reduced to four general ones; viz.

1st. It may be, that one body only is in motion at the time of the stroke.

2nd. They may both move one and the same way.

3rd. They may move in direct opposition to each other, and that with equal quantities of motion.

4th. They may be carried with unequal motions in directions contrary to each other.

As the bodies may be either equal or unequal, each of these four general cases may be considered as consisting of two branches.

As to the first, if a body in motion strikes another equal body at rest, they will, according to the proposition, move together each of them with one half of the motion that the body had which was in motion before the stroke; and since the quantity of motion in any body is as the product arising from the multiplication of its quantity of matter into its velocity, the common velocity of the two bodies will be but one half of the velocity of the moving body before the stroke.

As to the second general case, where both the bodies are in motion before the stroke, and move one and the same way. In order to find their common velocity after impact, let the sum of their motions before the stroke be divided by the sum of the bodies, and the quotient will express the common velocity.

As to the third general case, where the bodies move in direct opposition to each other, if they have equal quantities of motion, they will upon the stroke lose all their motion, and continue at rest; for, by the proposition, the bodies after impact will be carried with the difference of their motions before the stroke; which difference, in such a case, is nothing.

When two bodies meet with unequal quantities of motion, if the difference of their motions be divided by the sum of the bodies, the quotient will express their common velocity after the stroke; for, by the proposition, the difference of their motions before the stroke is equal to the sum of their motions after the stroke; consequently, that difference divided by the sum of the bodies must give the velocity.

Such are the principal laws which govern the collision of bodies devoid of elasticity. The motions of elastic bodies are determined by different rules: for when they are perfectly elastic, the velocity gained by the body struck, and the velocity lost by the striking body, will be twice as great as if the bodies were perfectly inelastic. In estimating, therefore, the motions of such bodies, we may first consider what they would have been after impact, had they been inelastic, and thence deduce the desired conclusion. See Helsham's Lectures, a work in which the subject appears to be very clearly treated.

## NOTE 26. p. 185.

Karn-breh hill rises a little to the south-west of Redruth in Cornwall, to an elevation of 697 feet. Its principal interest is derived from the speculations of the antiquary Doctor Borlase, who regarded it as having been once the grand centre of druidical worship; and he asserts, in his Antiquities of Cornwall, that, at this very time, the remains of those monuments which were peculiar to that priesthood may be discovered, such as *rock-basins, circles, rock-idols, cromlechs, karns, caves, religious enclosures, logan stones, a gorseddau*, or place of elevation, whence the druids pronounced their decrees, and the traces of a *grove of oaks*. This is all very ingenious and imposing, and may be easily believed by those who have either not visited the spot, or, having visited it, not viewed the objects with geological eyes. There is no ground whatever for considering the druidical monuments of Dr. Borlase as the works of man; on the contrary, they are evidently the results of the operation of time and the elements, the usual agents employed by Nature in the decomposition of mountain masses: but the age of antiquarian illusion is past; the light of geological science has dispelled the phantoms created by the wizard fancy, just as the rising sun dissolves the mystic forms which the most common object assumes in twilight, when viewed through the medium of credulity and superstition. The "rock-basins" of antiquaries are rounded cavities on the surface of rocks, and are occasionally as spheroidal internally as if they had been actually formed by a turning-lathe. It was this artificial appearance which first suggested the hypothesis concerning their origin, and induced the antiquary to regard them as pools of lustration. It may, however, be remarked, in the first place, that supposing them to have been the works of the druids, these priests must have been indefatigable artists, for there is scarcely a block of granite on which one or more of such pools are not visible, although some are, undoubtedly, much more complete and imposing than others. We shall introduce to the reader an account of these rock-basins in the words of their great defender, and we think that he will be amused with the ingenuity and confidence with which the antiquary dwells upon every appearance, and bends the facts to suit his favourite theory. "Since no author has mentioned, and attempted to explain these monuments, let us see what light and assistance their shape and structure, exposition, number, and place, considered together with the customs and known rites of antiquity, may afford us in this untrodden path. Of these basins there are two sorts; some have lips or channels to them, others have none; and therefore, as those lips are manifestly the works of design, not of accident, those that have so material a difference must needs have been intended for a different use, and yet both these sorts seem to be the works of the same people, for there is a multitude of these basins which have no lips or outlets, as well as those which have, to be seen on Karn-brêh hill, and elsewhere, on contiguous rocks. Their shape is not uniform; some are quite irregular, some oval, and some are exactly circular. Their openings do not converge in the top as a jar or hogshead, but rather spread and widen, as if to expose the hollow as much as possible to the skies. Some have little falls into a larger basin, which receives their tribute, and detains it, having no outlet. Other large ones intermixed with little ones have passages from one to another, and by successive falls uniting, transmit what they receive into one common basin, which has a drain to it, that serves itself and all the basins above it.

"The lips do not all point in the same direction, some tending to the south, some to the west, others to the north, and others again to the intermediate points of the compass, *by which it seems as if the makers had been determined in this particular, not by any mystical veneration for one region of the heavens more than another, but by the shape and inclination of the rock, and for the most easy and convenient outlet.*" We must here beg the reader to pause. The above remark is really too valuable to be suffered to pass without some notice. And so the absence of all design and arrangement is adduced as a proof of their artificial origin! What would Dr. Borlase have said, had all these lips been found to point in the same direction? But to proceed:

"The size of rock-basins is as different as their shape; they are formed from six feet to a few inches in diameter. Many uses may suggest themselves to the imaginations of the curious from the description of these new, and hitherto scarce-mentioned monuments; in order, therefore, to obviate some prepossessions, and prevent the mind from resting so far on groundless suppositions as may make it more difficult to embrace the truth, I shall first consider what, in all probability, *cannot* have been the design of them."

The doctor then proceeds to show that they could never have been intended for evaporating salt; nor for pounding tin ore, nor for receiving obelisks, or stone deities, nor for altars; and then suggests that they could be no other than vessels most ingeniously contrived for holding holy-water for the rites of washing and purification. "If," adds the learned antiquary, "fitness can decide the use, and where history is deficient, it is all reason that it should, we shall not long be at a loss. They are mostly placed above the reach of cattle, frequently above the inspection of man; nay, the stones which have these basins on them, do not touch the common ground, but stand on other stones.—Wherefore? but that the water might neither be really defiled by the former, nor incur the imaginary impurity, which touching the ground, according to the druid opinion, gave to every thing that was holy." We do not know what ideas the druids entertained with respect to the purity of water, but we have seen water in some of these pools so impregnated with the excrement of sea-birds, that we must have been as thirsty as Tantalus, before we could have been induced to cool our tongues with it.

"But," adds Dr. Borlase, "there are some basins which have no lip or channel; and, therefore, as they could not contribute any of their water to the common store, they *must* have been appropriated to another use, and since these are found in the same places with the others above-mentioned which have outlets or mouths to them, they must have been subservient to the same system of superstition, though in a different method.

"These basins are sometimes found near twenty feet high from the common surface; and, therefore, being so withdrawn from vulgar eyes, so elevated from the ground, which was supposed, as I said before, to defile all, they had likely a proportionably greater degree of reverence, and their waters accounted more holy, and more efficacious."

We shall not trouble the reader with any further quotations from this learned antiquary, except in concluding the history, after the fashion of melo-dramatists, with a splendid scene, in which, with the author's assistance, we shall bring all the performers on the stage, dressed in appropriate costume, and surrounded by all the pomp of druidical worship.

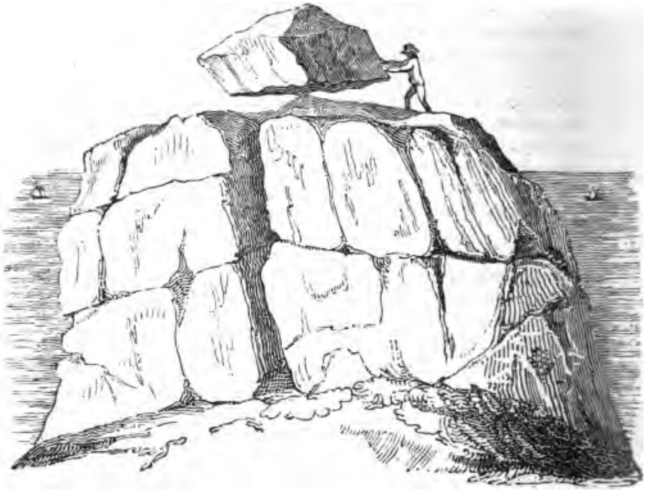
"From these basins," says Dr. Borlase, "on solemn occasions, the officiating druid, standing on an eminence, sanctified the congregation with a more than ordinarily precious lustration before he expounded to them, or prayed for them, or gave forth his decisions. This water he drank, or purified his hands in, before it touched any other vessel, and was consequently accounted more sacred than the other holy-water. To these more private basins, during the time of libation, the priest might have recourse, and be at liberty to judge by the quantity, colour, motion, and other appearances in the water, of future events, of dubious cases, without danger of contradiction from the people below. This water might serve to mix their mistletoe withal, as a general antidote: for, doubtless, those who would not let it touch the ground, would not mix this their divinity (the mistletoe) with common water. Oak leaves, without which the druid rites did scarce ever proceed, ritually gathered and infused, might make some very medicinal or incantorial potion. Lastly, libations of water were never to be made to their gods, but when they consisted of this purest of all water, as what was immediately come from the heavens, and partly therefore thither to be returned, before it touched any other water or any other vessel whatsoever, placed on the ground.

"As *logan*, or rocking-stones, were some of the *piæ fraudes* of the druids, the basins found on them might be used to promote the juggle; by the motion of the stone the water might be so agitated, as to delude the enquirer by a pretended miracle; might make the criminal confess; satisfy the credulous; bring forth the gold of the rich, and make the injured, rich as well as poor, acquiesce in what the druid thought proper."

Sorry are we to destroy a web which has been so ingeniously woven by its author; but the interests of truth admit not of compromise. Dr. Macculloch, in an interesting paper, published in the Transactions of the Geological Society, on the decomposition of the granite tors of Cornwall, has justly observed, that the true nature of these rock-basins may be easily traced by inspecting the rocks themselves. On examination, they will always be found to contain distinct grains of *quartz*, and fragments of the other constituent parts of the granite. A small force is sufficient to detach from the sides of these cavities additional fragments, showing that a process of decomposition is still going on under favourable circumstances. The principal of these circumstances is the presence of water, or rather the alternate action of air and water. If a drop of water can only make an effectual lodgement on a surface of this granite, a small cavity is sure to be sooner or later produced; this will insensibly enlarge as it becomes capable of holding more water; and the sides, as they continue to waste, will necessarily retain an even and rounded cavity, on account of the uniform texture of the rock. This explanation is sufficiently satisfactory: in addition to which, it may be stated, that these very basins not unfrequently occur on the perpendicular sides of rocks, as may be distinctly seen in the granite of Scilly, and in the gritstone rocks in the park of the late Sir Joseph Banks, in the parish of Ashover, in Derbyshire; a fact which at once excludes the idea of their artificial origin.

The other grotesque and whimsical appearances of rocky masses, such as *rock idols, logan stones, &c.* are to be explained by the tendency which granite possesses of wearing more rapidly on the angles and edges than on the sides; thus, then, upon simple and philosophical principles, are such appearances to be satisfactorily accounted for, and the *phantasmagoria* of Borlase vanishes as the light penetrates the theatre so long dedicated to its exhibition.

We shall conclude this note with a few observations upon the celebrated logan, or logging, stone, near the Land's End, Cornwall, of which we present our readers with a faithful sketch.



The foundation of this part of the coast is a stupendous group of granite rocks, which rise in pyramidal clusters to a great altitude, and overhang the sea. The celebrated *logan stone* here represented is an immense block weighing above sixty tons. The surface in contact with the under rock is of very small extent, and the whole mass is so nicely balanced, that, notwithstanding its magnitude, the strength of a single man applied to its under edge is sufficient to make it oscillate. It is the nature of granite to disintegrate into rhomboidal and tabular masses, which, by the further operation of air and moisture, gradually lose their solid angles, and approach the spheroidal form. The fact of the upper part of the cliff being more exposed to atmospheric agency than the parts beneath, will sufficiently explain why these rounded masses so frequently rest on blocks which still preserve the tabular form; and since such spheroidal blocks must obviously rest in that position in which their lesser axes are perpendicular to the horizon, it is equally evident that, whenever an adequate force is applied, they must vibrate on their point of support.

Although we are thus led to deny the druidical origin of this stone, for which so many zealous antiquaries have contended, still we by no means intend to deny that the Druids employed it as an engine of superstition; it is possible that, having observed so curious a property, they dexterously contrived to make it answer the purposes of an ordeal, and by regarding it as the *touch-stone* of truth, acquitted or condemned the accused by its motions. Mason poetically alludes to this supposed property in the following lines:—

> "Behold yon huge
> And unknown sphere of living adamant,
> Which, poised by magic, rests its central weight
> On yonder pointed rock; firm as it seems,
> Such is its strange and virtuous property,
> It moves obsequious to the gentlest touch
> Of him whose heart is pure, but to a traitor,
> Tho' e'en a giant's prowess nerved his arm,
> It stands as fixed as Snowdon."

## NOTE 27. p. 189.

We are indebted to Sir Everard Home for a description of that peculiar structure, by which several species of animals are enabled to sustain their bodies in opposition to the force of gravity. His first paper upon this subject is published in the 106th volume of the Philosophical Transactions, in which he says, he was not aware that any animal, larger than the house-fly, was endowed by nature with such a power, so as to admit of examination, until Sir Joseph Banks mentioned that the *lacerta gecko*, a species of lizard, which is a native of the island of Java, comes out of an evening from the roofs of the houses, and walks down the smooth, hard, and polished chinam walls, in search of the flies which settle upon them, and which are its natural food, and then runs up again to the roof of the house. Sir Joseph, while at Batavia, amused himself with catching this animal, by standing close to the wall, at some distance from the lizard, with a long flattened pole, which being made suddenly to scrape the surface of the wall, knocked the animal down. He presented Sir Everard with a specimen weighing five ounces and three quarters, avoirdupois, which enabled him to ascertain the peculiar mechanism by which the feet of this animal can keep their hold of a smooth, hard, perpendicular wall, and carry up so large a weight as that of its body.

The foot has five toes, at the end of each of which, except that of the thumb, is a very sharp and much curved claw; on the under surface of each toe are sixteen transverse slits, leading to so many cavities or pockets, the depth of which is nearly equal to the length of the slit that forms the orifice; they all open forward, and the external edge of each opening is serrated, like the teeth of a small-toothed comb. The cavities, or pockets, are lined with a cuticle, and the serrated edges are also covered with it. The structure just described is supplied with various muscles, whose action is to draw down the claw, open the orifices of the pockets, and turn down the serrated edges upon the surface on which the animal stands. Upon examining attentively the under surfaces of the toes, when the pockets are closed, Sir Everard Home was struck with their resemblance to the surface of that portion of the *echineis remora*, or sucking fish, by which it attaches itself to the shark, or to the bottom of ships; and it consequently suggested the probability of obtaining, from an examination of this latter apparatus, much useful information which might be applicable to the subject of the lizard, more especially as the parts of which it is composed are so much larger, and therefore more within the reach of anatomical examination.

The surface on the top of the head of this fish, fitted for adhesion, is of an oval form, and bears a considerable proportion to the size of the whole animal; it is surrounded by a broad, loose, movable edge, capable of applying itself closely to the surface on which it is placed; and it is evident that when the external edge is so applied, and the cartilaginous plates are raised up, the interstices must become so many vacua, and the serrated edge of each plate will keep a sufficient hold of the substance on which it rests to retain it in that position, assisted by the pressure of the surrounding water, without a continuance of muscular exertion. It thus appears that the adhesion of the *sucking fish* is produced by so many vacua being formed through an apparatus worked by the voluntary muscles of the animal, and the pressure of the surrounding water.

From the similarity of the mechanism of the under surface of the toes of the *lacerta gecko*, there can be no doubt that the purpose to which it is applied is the same: but as in the one case the adhesion is to take place under water, and is to continue for longer periods, the means are more simple; in the other, where the mechanism is to be employed in air, under greater disadvantages with respect to gravity, and is to last for very short periods, and then immediately afterwards to be renewed, a more delicate structure of parts, a greater proportional depth of cavities, and more complex muscular structure, become necessary.

Having ascertained the principle on which an animal of so large a size as the *lacerta gecko* is enabled to support itself in its progressive motion against gravity, Sir E. Home felt himself more competent to inquire into the mechanism by which the common fly is enabled, with so much facility, to support itself in still more disadvantageous situations. In the natural size, the feet of the fly are so small, that nothing can be determined respecting them; Keller was the first person who made a drawing of the fly's foot in a highly magnified state, in which the concave surfaces are visible, and which, no doubt, like those of the lizard above described, are employed to form vacua, which enable the fly to move under such disadvantageous circumstances. Mr. Bauer, who has so greatly distinguished himself in microscropic researches, was judiciously enlisted into the service of Sir E. Home upon this occasion; and he has shown that this principle, on which progressive motion against gravity depends, is very extensively employed by nature in the structure of the feet of insects; and Sir Everard observes, that now this structure is known, it can be readily demonstrated by looking at the movement of the feet of any insect upon the inside of a glass tumbler, through a common magnifying glass; the different suckers are readily seen separately to be pulled off from the surface of the glass, and reapplied to another part.

In consequence of the expedition to the polar regions, Sir E. Home was enabled to obtain and examine the foot of the walrus, in which he detected a resemblance in structure to that of the fly; and it is not a little curious that two animals so different in size should have feet so similar in their use. In the fly, the parts require to be magnified one hundred times to render the structure distinctly visible; and in the walrus the parts are so large, as to require being reduced four diameters, to bring them within the size of a quarto page.

Nor is progressive motion, the only function in which nature avails herself of the pressure of the atmosphere for the accomplishment of her purposes. The act of feeding is continually effected in this manner. The operation of sucking is too familiar to require comment. It may not, perhaps, be so generally known that it is by the very same process that bees reach the fine dust and juices of hollow flowers, like the honeysuckle, and some species of foxglove, which are too narrow to admit them. They fill up the mouth of the flower with their bodies, and suck out the air, or at least a large portion of it, by which the soft sides of the flower are made to collapse, and the juice and dust are squeezed towards the insect, as completely as if the hand had pressed it externally.

## NOTE 28. p. 194.

Those who are not acquainted with the operations by which the mind is enabled to arrive at truth, are too apt to attribute to accident that which is the result of great intellectual labour and acuteness. Observation, analogy, and experiment are the three great stepping-stones by which the philosopher is enabled to ascend from darkness to light: it is true that his foot may accidentally be placed upon the first, but his own efforts are required to complete the ascent. To the mass of mankind the preliminary step is obvious, and they, at once, conclude that the succeeding ones are equally easy and simple. In this view of the subject, it was by accident that Sir Isaac Newton discovered the laws of gravitation, for his mind was directed to the investigation by the accidental fall of an apple from its tree; it was by accident that Galileo discovered the isochronous movement of the pendulum, for it was suggested by the vibration of a chandelier: but how many persons might have witnessed the fall of an apple, or the vibration of a chandelier, without arriving at similar truths? It has been said that we are indebted for the important invention in the steam-engine, termed *hand gear*, by which its valves or cocks are worked by the machine itself, to an idle boy of the name of Humphrey Potter, who, being employed to stop and open a valve, saw that he could save himself the trouble of attending and watching it, by fixing a plug upon a part of the machine which came to the place at the proper times, in consequence of the general movement. If this anecdote be true, what does it prove? That Humphrey Potter might be very idle, but that he was, at the same time, very ingenious. It was a contrivance, not the result of accident, but of acute observation and successful experiment. Glass is said to have been discovered by persons having accidentally kindled a fire on the sandy shore with sea weed, when the alkali from the ashes united with the silex of the sand; and Pliny tells us that *minium*, or red lead, was first recognised, in consequence of a fire that took place at the Piræus at Athens, where some *ceruse*, which had been exposed to the fire, had been found converted into a red substance. A thousand such accidents might be related, were we not affording a sample rather than a catalogue. We are endeavouring to combat a popular but mischievous error; and we are happy at finding the same feeling expressed in a work which, from its extensive circulation, must prove highly useful in correcting it. "Very few discoveries," says the author, "have been made by chance and by ignorant persons; much fewer than is generally supposed. They are generally made by persons of competent knowledge, and who are in search of them. The improvement of the steam-engine by Watt, resulted from the most learned investigation of mathematical, mechanical, and chemical truths. Arkwright devoted many years, five at least, to his invention of spinning-jennies. The new process of refining sugar, by which more money has been made in a shorter time, and with less risk and trouble, than was perhaps ever gained by an invention, was discovered by

Mr. Howard, a most accomplished chemist, and it was the fruit of a long course of experiments, in the progress of which, known philosophical principles were constantly applied, and one or two new principles ascertained."—*Library of Useful Knowledge.*

### NOTE 29. p. 200.

Hence *pecunia* from pecus. *Opes* quasi Oves. See Note 6.

### NOTE 30. p. 209.

If a soap-bubble be blown up, and set under a glass, so that the motion of the air may not affect it, as the water glides down the sides and the top grows thinner, several colours will successively appear at the top, and spread themselves from thence in rings down the sides of the bubble, till they vanish in the same order in which they appeared; at last a black spot appears at the top, and spreads till the bubble bursts. Hence it follows that the colours of a body depend in some degree upon the thickness and density of the particles that compose it; and that if the density be changed the colour will likewise be changed. That the production of colours depends upon the nature of the surfaces upon which light falls, is beautifully exemplified by the iridescence of mother of pearl; and which has been satisfactorily shown to depend upon a singular peculiarity in the structure of that substance. On its surface, which to the unassisted eye, and even to the touch, appears to be finely polished, there are innumerable little lines, or *grooves*, in some places as many as two or three thousand in the space of an inch, which, lying parallel, regularly follow each other in all their windings; by the edges of which the rays of light are reflected, and the continual change of colour arises from their continual bendings. Whatever doubts might have existed upon the subject, some late experiments of Dr. Brewster have dissipated them, by showing that the colours which play so beautifully on the surface of mother of pearl, may be communicated by pressure to sealing-wax and several other substances. The discovery of this fact was in some measure accidental; he had stuck a piece of mother of pearl on a cement made of rosin and bees-wax, and on separating this cement he found that it had acquired the property of exhibiting colours. Several persons who witnessed the effect, concluded that it arose from the presence of a thin film of the mother of pearl, which might have scaled off and adhered to the wax: but such an explanation was at once refuted, by plunging the wax in acid, which must have dissolved the mother of pearl, had any been present; but the acid had no effect, and the colours of the impression remained unimpaired. It is clear, then, that it is the grooves, as Dr. Brewster conjectured, which occasion the iridescence in the mother of pearl, as well as in the waxen impression. In consequence of this curious discovery, Mr. Barton succeeded in producing the same appearance on glass, and on different metals, by simply cutting grooved lines on their surface. These lines are so fine that, without a microscope, they are scarcely visible, and the glass and the metal appear to retain their polish; yet they and the colours also may be communicated by an impression, like those from the mother of pearl, to the wax.

### NOTE 31. p. 227.

The following are a few of those plants which indicate changes in the weather:—

*Chickweed* is an excellent barometer. When the flower expands fully, we are not to expect rain for several hours; should it continue in that state, no rain will disturb the summer's day. When it half conceals its miniature flower, the day is generally showery; but, if it entirely shuts up, or veils the white flower with its green mantle, let the traveller take the hint and put on his great coat. The different species of *trefoil* always contract their leaves at the approach of a storm; so certainly does this take place, that these plants have acquired the name of the *husbandman's barometer*.

The tulip and several of the compound yellow flowers also close before rain. There is, besides, a species of wood-sorrel, which doubles its leaves before storms and tempests. The *bauhinia*, or mountain ebony, *cassia*, and sensitive plants, observe the same habit.

### NOTE 32. p. 228.

The popular adage of *Forty days' rain after St. Swithin*, is a tradition which seems to have derived its origin from the following circumstance. Swithin, or *Swithum*, bishop of Winchester, who died in 868, desired that he might be buried in the open church-yard, and not in the chancel of the minster, as was usual with other bishops; and his request was complied with; but the monks, on his being canonized, considering it disgraceful for the saint to lie in a public cemetery, resolved to remove the body into the choir, which was to have been done with solemn procession on the 15th of July. It rained, however, so violently for forty days together at this season, that the design was abandoned. "Now, without entering into the case of the bishop," says Mr. Howard, in his work on the Climate of London, "who was probably a man of sense, and wished to set the example of a more wholesome, as well as a more humble, mode of resigning the perishable clay to the destructive elements, I may observe, that the fact of the hindrance of the ceremony by the cause related is sufficiently authenticated by tradition; and the tradition is so far valuable, as it proves that the summers in this southern part of our island, were subject, a thousand years ago, to occasional heavy rains, in the same way as at present." Mr. Howard has shown, by a table, that the notion commonly entertained on this subject, if put strictly to the test of experience, at any one station, in this part of the island, will be found fallacious; he, however, very justly observes, that "the opinion of the people on subjects connected with Natural History is commonly founded, in some degree, on fact or experience;" and to do justice to the popular observation in question, he states that, "in a majority of our summers, a showery period, which, with some latitude as to time and local circumstances, may be admitted to constitute daily rain for forty days, does come on about the time indicated by this tradition; not that any long space before is often so dry as to mark distinctly its commencement."

## NOTE 33. p. 232.

Did the whale know his own power, he would easily destroy all the machinery which the art of man could devise for catching him; it would be only necessary for him to swim on the surface in a straight line in order to break the thickest rope; but the fish, on being struck by the harpoon, obeys a natural instinct which, in this instance, betrays him to his death. Sir H. Davy, in his Salmonia, observes, that the whale not having an air bladder, can sink to the lowest depths of the ocean, and mistaking the harpoon for the teeth of a sword-fish, or a shark, he instantly descends, this being his manner of freeing himself from these enemies, who cannot bear the pressure of a deep ocean; and from ascending and descending in small space, he thus puts himself in the power of the whaler.

### NOTE 34. p. 239.

This fact may be demonstrated by converting the triangle into a parallelogram, of which one of the sides of the triangle will become its diagonal: the other two sides will, of course, represent two forces equivalent to such diagonal, which, acting in opposition to it, must produce a balance.

### NOTE 35. p. 243.

The curious experiments of Mr. Faraday upon the optical effects produced by the revolutions of different wheels, might be exhibited by arrangements adjusted as messengers.

### NOTE 36. p. 247.

The sea and land breezes which occur in the islands of the torrid zone, very strikingly illustrate the position laid down in the text, and afford a good explanation of the manner in which winds may be occasioned by a change of temperature in the air. In these, during the hottest part of the day, the wind sets in from all quarters, and appears to be blowing towards the centre of the island, while in the night it changes its direction, and blows from the centre of the land towards the sea; for since the sun's rays produce much more heat by their reflection from land than they do from water, that portion of air which is over the land will soon become heated, and will ascend; a rarefaction and diminution of the quantity of air over the central part of the land will be thus occasioned, which must be supplied from the sides; but, as the land cools again during the night, that portion of air which had been previously heaped up will begin to descend, and by spreading and equalizing itself will produce a breeze blowing from the centre.

The *trade-winds*, so called from the advantage which their certainty affords to trading-vessels, are another example of the same kind; they are generally stated to blow from east to west over the equator, and are occasioned by the rarefaction of the air by the sun's heat, and the motion of the earth from west to east. While writing the present note, we have seen an essay upon the subject by Captain Basil Hall, published in an appendix to Mr. Daniel's admirable work on Meteorology; the perusal of this paper has induced us to cancel what we had written, and to refer the reader to the essay itself; for it is quite impossible to do justice to the views it entertains, in the limited space necessarily prescribed to us in this note.

On the coast of Guinea, the wind always sets in upon the land, blowing westerly instead of easterly; this exception arises from the deserts of Africa, which lie near the equator, and being a very sandy soil reflect a great degree of heat into the air above them, which being thus rendered lighter than that which is over the sea, the wind continually rushes in upon the land to restore the equilibrium.

Among the irregular winds, or those which are not constant, but accidental, may be noticed the *whirlwind*, the *harmattan*, and the *sirocco*. The first of these is occasioned by the meeting of two or more currents of wind from opposite directions, and which can only be occasioned by some temporary but violent disturbance of equilibrium. The *harmattan* is met with on the western coast of Africa, and is generally attended by great heat and fog; it appears to be occasioned by a conflict between the heated sands of Africa, and the regular direction of the trade-winds over that continent, and by disturbing their progress, it is frequently the forerunner of a hurricane in the West Indies. The *sirocco* occurs in Egypt, the Mediterranean, and in Greece, and is chiefly characterised by its unhealthy qualities. The air, by passing over the heated sands of Egypt becomes so dried and rarefied as to be scarcely fit for respiration, and being so prepared, it absorbs so much humidity on passing the Mediterranean as to form a suffocating and oppressive kind of fog.

Mr. Daniel observes, that the currents of a heated room, in some measure, exemplify the great currents of the atmosphere. If the door be opened, the flame of a candle held to the upper part will show, by its inclination, a current flowing outwards; but, if held near the floor, it will be directed inwards. If the door be closed suddenly from without, it moves with the in-coming current, and against the out-going, and a condensation of air takes place in the room, which is proved by the rattling of the windows, and the bursting open of any door in the room, if slightly closed. If the door close from within, it moves against the in-coming current, and with the out-going, and a rarefaction of the air in the room takes place, which is evidenced by the rattling of the windows, and the bursting open of another door in the contrary direction.

### NOTE 37. p. 252.

We are reminded, upon this occasion, of part of a stanza in the well-known ballad of Chevy Chace, where an English archer aimed his arrow at Sir Hugh Montgomery:—

> " The *grey goose wing* that was thereon,
> In his hearte's blood was wett."

The more ancient ballad, however, reads *swane-feathers.* In the " Geste of Robyn Hode," among Mr. Garrick's old plays, in the Museum, the arrows of the outlaw and his companions are particularly described :—

> " With them they had an hundred bowes,
> The strings were well ydight;
> An hundred shefe of arrows good,
> With hedes burnish'd full bryght;
> And every arrowe an ell longe,
> With *peacocke* well ydight,
> And rocked they were with white silk,
> It was a semely sight."

And Chaucer, in the description of the squyer's yeoman says :—

> " And he was clad in cote and hode of greene;
> A sheafe of *peacocke* arrows bryght and shene,
> Under his belt he bare full thriftely,
> Well coude he dresse his tackle yemanly:
> His arrowes drouped not with fethers lowe,
> And in his hand he bare a mighty bowe."
> *Prol. to Cant. Tales.*

In order to show the dandyism displayed by the archers of former times, it may be stated, that, in the wardrobe accounts of the 28 Edw. I. p. 359. is a charge of verdigrise to stain the feathers of the arrows green. A wardrobe account of the 4 Edw. II. furnishes an entry for peacock arrows, " Pro duodecim flecchiis cum pennis de *pavone,* emptis pro rege de 12 den."

As this note has some connexion with the shuttlecock, as well as the arrow, we may take this opportunity of introducing a passage, which was accidentally omitted in the text; it refers to the method of playing this game at Turon, in Cochin China; and which is described by a traveller as follows:—"Instead of using a battledoor, as is the custom in England, the players stood seven or eight in a circle; and, after running a short race, and springing from the floor, they met the descending shuttlecock with the sole of the foot, and drove it up again with force high in the air. The game was kept up with much animation, and seldom did the players miss their stroke, or give it a wrong direction. The shuttlecock was made of a piece of dried skin rolled round, and bound with strings. Into this skin were inserted three feathers, spreading out at top, but so near to each other, where they were stuck into the skin, as to pass through the holes, little more than a quarter of an inch square, which were always made in the centre of Cochin copper coins. We made one or two awkward attempts at the game, not only to our own confusion, but much to the amusement of the natives. It must, however, be remembered, that, amongst these ingenious people, the feet assist, as auxiliaries to the hands, in the exercise of many trades, particularly that of boat-building."

### Note 38. p. 273.

A beautiful experiment was lately instituted at Paris, to illustrate this fact, by Biot. At the extremity of a cylindrical tube, upwards of 3000 feet in length, a ring of metal was placed, of the same diameter as the aperture of the tube; and in the centre of this ring, in the mouth of the tube, was suspended a clock bell and hammer. The hammer was made to strike the ring and the bell at the same instant, so that the sound of the ring would be transmitted to the remote end of the tube through the conducting power of the matter of the tube itself; while the sound of the bell would be transmitted through the medium of the air included within the tube. The ear being then placed at the remote end of the tube, the sound of the ring, transmitted by the metal of the tube, was first distinctly heard; and, after a short interval had elapsed, the sound of the bell, transmitted by the air in the tube, was heard. The result of several experiments was, that the metal of the tube conducted the sound with about ten and a half times the velocity with which it was conducted by the air; that is, at the rate of about 11,865 feet per second.

## NOTE 39. p. 292.

The biographer of Josquin des Prez, the celebrated musician, and *maestro di capella* to Louis XII. King of France, relates an anecdote which may be here told in connexion with the present subject. When Josquin was first admitted into the service of the French monarch, he had been promised a benefice by his Majesty; but this Prince, contrary to his usual habits, for he was in general both just and liberal, forgot the promise he had made; when Josquin, after suffering great inconvenience from the shortness of his Majesty's memory, ventured by the following expedient to remind him publicly of his promise without giving offence. He had been commanded to compose a motet for the Chapel Royal, on which occasion he selected part of the 119th Psalm, "*Memor esto verbi tui servo tuo.*"—"*Oh think of thy servant, as concerning thy word,*" which he set in so supplicating and exquisite a manner, that it was universally admired, particularly by the King, who was not only touched by the music, but felt the words so effectually that he soon afterwards granted his petition, by conferring on him the promised preferment. For which act of justice and munificence, Josquin, with equal felicity, composed as a hymn of gratitude another part of the same Psalm.—"*Bonitatem fecisti cum servo tuo, Domine.*"—"*Oh Lord, thou has dealt graciously with thy servant.*"

Josquin, among musicians, was the giant of his time, and seems to have arrived at universal monarchy and dominion over the affections and passions of the musical part of mankind; indeed, his compositions were as well known, and as much practised throughout Europe, at the beginning of the sixteenth century, as those of Handel were in Europe sixty years ago.

## NOTE 40. p. 298.

The following case, quoted by Sir David Brewster, in his work on "Natural Magic," from the life of Peter Heaman, a Swede, who was executed for piracy and murder at Leith in 1822, will afford a very curious example of the influence of the imagination in creating distinct forms out of an irregularly shaded surface. "One remarkable thing was, one day as we mended a sail, it being a very thin one, after laying it upon deck in folds, I took the tar-brush and tarred it over in the places which I thought needed to be strengthened. But when we hoisted it up, I was astonished to see that the tar I had put upon it represented a gallows and a man under it without a head. The head was lying beside him. He was complete, body, thighs, legs, arms, and in every shape like a man. Now, I oftentimes made remarks upon it, and repeated them to the others. I always said to them all, 'You may depend upon it that something will happen.' I afterwards took down the sail on a calm day, and sewed a piece of canvass over the figure to cover it, for I could not bear to have it always before my eyes."

### NOTE 41. p. 302.

In order to comprehend the nature of *reciprocated vibraton*, or *resonance*, let the reader keep in his remembrance the analogy between musical vibration, and the oscillation of the pendulum, as explained at page 78. If he well understands the phenomena of the latter, he will readily comprehend those of the former. Galileo observed that a heavy pendulum might be put in motion by the least breath of the mouth, *provided the blasts were often repeated, and made to keep time exactly with the vibrations of the pendulum*—from the same sympathetic communication of vibrations will two pendulum clocks fixed to the same wall, or two watches lying upon the same table, take the same rate of going, though they would not agree with one another, if placed in separate apartments. Mr. Ellicot indeed observed that the pendulum of one clock was even able to stop that of the other, and that the stopped pendulum, after a certain time, would resume its vibrations, and in its turn stop the vibrations of the other. We have here a correct explanation of the phenomena of *Resonance;* for the undulations excited by a vibratory body are themselves capable of putting in motion all bodies whose pulses are coincident with their own, and consequently with those of the primitive sounding body; hence the vibrations of a string when another tuned in unison with it is made to vibrate.

Upon the same principle does the resonance, or reciprocated vibrations of columns of air depend. We are much indebted to Mr. Wheatstone for our knowledge of this branch of acoustics; he has shown that, if a tuning-fork, or a bell, be sounded before a tube inclosing a column of air of the necessary length, the original sound will be augmented by the rich resonance of that air; and that the sounds of tuning-forks, if held before the cavity of the mouth, may be reciprocated most intensely by adjusting the alterable volume of air contained within it to the pitch of the instrument; by placing, for instance, the tongue, &c. in the position for the nasal continuous sound of *ng* (in song) and then altering the aperture of the lips, until the loudest sound was obtained, he readily accomplished his object.

If two vibrating tuning-forks, differing in pitch, be held over a closed tube, furnished with a moveable piston, either sound may be made to predominate, by so altering the piston as to obtain the exact column of air which will reciprocate the required sound. The same result may be obtained by selecting two bottles (which may be tuned with water) each corresponding to the sound of a different tuning-fork; on bringing both tuning-forks to the mouth of each bottle, alternately, that sound only will be heard, in each case, which is reciprocated by the unisonant bottle; or, in other words, by that bottle which contains a column of air, susceptible of vibrating in unison with the fork.

Among the Javanese instruments brought to England by the late Sir Stamford Raffles, there is one called the *gender*, in which the resonances of columns of air are employed to augment, we might almost say to render audible, the sounds of vibrating metallic plates. Under each of these plates is placed an upright bamboo, containing a column of air of the proper length to reciprocate the lowest sound of such plate. If the aperture of the bamboo be covered with pasteboard, and its corresponding plate be struck, a number of acute sounds only (depending on the more numerous subdivisions of the plate) will be heard; but, on removing the pasteboard, an additional deep, rich tone is produced by the resonance of the column of air within the tube.

It is only by a knowledge of this principle that the theory of the Guimbarde, or Jew's Harp, can be well understood.

## NOTE 42. p. 303.

The Memoires of Madame de Genlis first made known the astonishing powers of a poor German soldier on the Jew's harp. This musician was in the service of Frederick the Great, and finding himself one night on duty under the windows of the king, played the Jew's harp with so much skill, that Frederick, who was a great amateur of music, thought he heard a distinct orchestra. Surprise on learning that such an effect could be produced by a single man with two Jew's harps, he ordered him into his presence; the soldier refused, alleging, that he could only be relieved by his colonel; and that, if he obeyed, the king would punish him the next day, for having failed to do his duty. Being presented the following morning to Frederick, he was heard with admiration, and received his discharge and fifty dollars. This artist, whose name Madame de Genlis does not mention, is called Koch; he has not any knowledge of music, but owes his success entirely to a natural taste. He has made his fortune by travelling about, and performing in public and private, and is now living retired at Vienna, at the advanced age of more than eighty years. He used two Jew's harps at once, in the same manner as the peasants of the Tyrol, and produced, without doubt, the harmony of two notes struck at the same moment, which was considered by the musically-curious as somewhat extraordinary, when the limited powers of the instrument were remembered. It was Koch's custom to require that all the lights should be extinguished, in order that the illusion produced by his playing might be increased.

It was reserved, however, for Mr. Eulenstein to acquire a musical reputation from the Jew's harp. After ten years of close application and study, this young artist has attained a perfect mastery over this untractable instrument. In giving some account of the Jew's harp, considered as a medium for musical sounds, we shall only present the result of his discoveries. This little instrument, taken singly, gives whatever grave sound you may wish to produce, as a *third*, a *fifth*, or an *octave*. If the grave tonic is not heard in the bass Jew's harp, it must be attributed, not to the defectiveness of the instrument, but to the player. In examining this result, you cannot help remarking the order and unity established by nature in harmonical bodies, which places music in the rank of exact sciences. The Jew's harp has three different tones; the bass tones of the first octave bear some resemblance to those of the flute and clarionet; those of the middle and high, to the *vox humana* of some organs; lastly, the harmonical sounds are exactly like those of the *harmonica*. It is conceived that this diversity of tones affords already a great variety in the execution, which is always looked upon as being feeble and trifling, on account of the smallness of the instrument. It was not thought possible to derive much pleasure from any attempt which could be made to conquer the difficulties of so limited an instrument; because, in the extent of these octaves, there were a number of spaces which could not be filled up by the talent of the player; besides, the most simple modulation became impossible. Mr. Eulenstein has remedied that inconvenience, by joining sixteen Jew's harps, which he tunes by placing smaller or greater quantities of sealing-wax at the extremity of the tongue. Each harp then sounds one of the notes of the gamut, diatonic or chromatic, and the performer can fill all the intervals, and pass all the tones, by changing the harp. That these mutations may not interrupt the measure, one harp must always be kept in advance, in the same manner as a good reader advances the eye, not upon the word which he pronounces, but upon that which follows.

### NOTE 43. p. 319.

This project has lately been revived; in a late number of the *Revue Encyclopédique* there is a proposal to communicate verbal intelligence, in a few moments, to vast distances, and thus not by symbols, as in the Telegraph, but in distinct articulate sounds uttered by the human voice. The plan is said to have originated with an Englishman, Mr. Dick, according to whose experiments the human voice may be made intelligible at the distance of twenty-five or thirty miles. It has been stated, in Note 38, that the celebrated Biot had ascertained that sound travels more then ten times quicker when transmitted by solid bodies, or through tubes, than when it passes through the open air; at the distance of more than half a mile the low voice of a man was distinctly heard. Father Kircher relates in some of his works, that the labourers employed in the subterranean aqueducts of Rome heard each other at the distance of several miles.

### NOTE 44. p. 319.

It has often occurred to the author of these pages, during his reveries, that the means of conveying intelligence with immense rapidity may be hereafter invented by the Electrician.—Should a system of railways be established throughout the country, it might lead to some expedient by which such a desideratum could be accomplished through the medium of electrical discharges. Upon this subject we have accidentally fallen upon a curious notice in Arthur Young's Travels in France (vol. i. p. 65.) "M. Lomond has made a very curious discovery in electricity; you write two or three words on a paper, he takes it with him into his room, and there turns a machine inclosed in a cylindrical case, at the top of which is an electromoter of pith balls; by means of a wire, a connexion is made with a similar cylinder and electromoter in a distant apartment, and his wife by remarking the corresponding motions of the balls, writes down the words they indicate; from which it appears that he has formed an *Alphabet of Motion*. As the length of the conducting wire makes no difference in the effect, a correspondence might be carried on at any distance, as for example, within or without a besieged town; or, for purposes much more interesting and useful. Whatever the uses may be, the invention is beautiful."

### Note 45. p. 366.

The *carrier* is a variety of the common domestic pigeon, and which, from the superior attachment that it shows to its native place, is employed in many countries as the most expeditious courier. The letters are tied under its wing, it is let loose, and in a very short space returns to the home it was brought from, with its advices. This practice was much in vogue in the East; and at Scanderoon, till of late years, it was used on the arrival of a ship, to give the merchants at Aleppo a more expeditious notice than could be done by any other means. In our own country, these aerial messengers have been employed for a very singular purpose, having been let loose at Tyburn at the moment the fatal cart was drawn away, to notify to distant friends, the departure of the unhappy criminal.

In the East, the use of these birds seems to have been greatly improved, by having, if we may use the expression, relays of them ready to spread intelligence to all parts of the country; thus it is stated by Ariosto (canto 15.) that the governor of Damiata circulated the news of the death of Orrilo. "As soon as the commandant of Damiata heard that Orrilo was dead, he let loose a pigeon, under whose wing he had tied a letter. This fled to Cairo, from whence a second was despatched to another place, as is usual; so that in a very few hours, all Egypt was acquainted with the death of Orrilo."

But the simple use of them was known in very early times. Anacreon tells us (ode ix.) that he conveyed his billet-doux to Bathyllus by a dove.

Taurosthenes also, by means of a pigeon he had decked with purple, sent advice to his father, who lived in the isle of Ægina, of his victory in the olympic games, on the very day he had obtained it.* And, at the siege of Modena, Hirtius without, and Brutus within the walls, kept, by the help of pigeons, a constant correspondence; baffling every stratagem of the besieger, Antony, to intercept their couriers. In the times of the crusades, there are many more instances of these birds of peace being employed in the service of war: Joinville relates one during the crusade of *Saint Louis*, and Tasso another, during the siege of Jerusalem. *Pennant's British Zoology*.

### NOTE 46. p. 369.

The soothsayers attributed many mystic properties to the coral; and it was believed to be capable of giving protection against the influence of *Evil Eyes:* it was even supposed that coral would drive away devils and evil spirits; hence arose the custom of wearing amulets composed of it around the neck, and of making crowns of it. Pliny and Dioscorides are very loud in the praises of the medicinal properties of this substance, and Paracelsus says that it should be worn round the necks of infants, as an admirable preservative against fits, sorcery, charms, and even against poison. It is a curious circumstance that the same superstitious belief should exist among the negroes of the West Indies, who affirm that the colour of coral is always affected by the state of health of the wearer, it becoming paler in disease. In Sicily it is also commonly worn as an amulet by persons of all ranks, as a security against an *evil eye* a small twisted piece, somewhat resembling a horn, is worn at the watch-chain, under the name of *Buon Fortuna*, and is occasionally pointed at those who are supposed to entertain evil intention. His late Sicilian Majesty was celebrated for his faith in, and frequent use of, the *buon fortuna*.—But to return to the coral usually suspended around the necks of children in our own country. In addition to the supposed virtues of the coral it may be remarked that silver bells are usually attached to it, which are generally regarded as mere accompaniments to amuse the child by their jingle; but the fact is, that they have a different origin, having been designed to frighten away evil spirits. For the same superstitious objects were bells introduced into our churches, as a species of charm against storms and thunder, and the assaults of Satan.

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* *Ælian. Var. Hist.* lib. ix. c. 2. Pliny, lib. x. c. 24. says, that swallows have been made use of for the same purpose.

In farther illustration of the truth, that a custom has frequently survived the tradition of its origin, it may be here observed that the common practice of persons, who are unable to write, making their mark or *cross*, is derived from our Saxon ancestors, who affixed the sign of the cross, as a signature to a deed, whether they could write or not. Several charters still remain, to which kings and persons of great eminence affix "*Signum Crucis manu propria pro ignorantia literarum.*" Hence is derived the expression of *signing* instead of *subscribing* a paper. In like manner, the physician of the present day continues to prefix to his prescriptions the letter R, which is generally supposed to mean *Recipe*, but which, in truth, is a relict of the astrological symbol of Jupiter, formerly used as a species of superstitious invocation.

### Note 47, p. 386.

This problem is to be found in Hutton's Recreations, and is stated as follows:—

"A person having in one hand an *even* number of shillings, and in the other an *odd*, to tell in which hand he has the even number.

"Desire the person to multiply the number in the right hand by any even number whatever, and that in the left by any odd number; then bid him to add together the two products, and if the whole sum be odd, the even number of shillings will be in the right hand, and the odd number in the left; if the sum be even, the contrary will be the case. By a similar process, a person having in one hand a piece of gold and in the other a piece of silver, we can tell in which hand he holds the gold, and in which the silver. For this purpose, some value represented by an even number, such as 8, must be assigned to the gold, and a value represented by an odd number, such as 3, must be assigned to the silver; after which the operation is exactly the same as in the preceding example.

"To conceal the artifice better, it will be sufficient to ask whether the sum of the two products can be halved without a remainder; for, in that case, the total will be even, and in the contrary case odd.

"It will be readily seen that the pieces, instead of being in the two hands of the same person, may be supposed to be in the hands of two persons, one of whom has the even number, or piece of gold, and the other the odd number, or piece of silver. The same operations may then be performed in regard to these two persons, as are performed in regard to the two hands of the same person, calling the one, privately, the right, and the other the left."

### NOTE 48. p. 387.

It is by discovering the number of counters left on the board that this trick is performed. By means of a table the problem may be immediately solved, but as such a reference would be inconvenient, and, indeed, destructive to the magic of the trick, a Latin verse is substituted, which may be easily carried in the memory, and will be found to answer all the purposes of a table. In order, however, that the reader may become thoroughly acquainted with the machinery of the trick, we shall explain it in the words of its author. The problem is stated as follows: "*Three things being privately distributed to three persons, to guess that which each has got.*"

Let the three things be a ring, a shilling, and a glove. Call the ring A, the shilling E, and the glove I; and in your own mind distinguish the persons by calling them first, second, and third. Then take twenty-four counters, and give one of them to the first person, two to the second, and three to the third. Place the remaining eighteen on the table, and then retire, that the three persons may distribute among themselves the three things proposed without your observing them. When the distribution has been made, desire the person who has the ring to take from the remaining eighteen counters as many as he has already; the one who has the shilling to take twice as many as he has already, and the person who has the glove to take four times as many; according to the above supposition then, the first person has taken one, the second four, and the third twelve; consequently, one counter only remains on the table. When this is done, you may return, and by the number left, can discover what thing each person has taken, by employing the following words:—

1 2 3 5 6 7
*Salve certa animæ semita vita quies.*

To make use of these words, you must recollect, that in all cases there can remain only 1, 2, 3, 5, 6, or 7 counters, and never 4. It must likewise be observed, that each syllable contains one of the vowels, which we have made to represent the things proposed, and that the first syllable of each word must be considered as representing the first person, and the second syllable the second. This being comprehended, if there remains only one counter, you must employ the first word, or rather the two first syllables, *sal-ve*, the first of which, that containing A, shows that the first person has the ring represented by A; and the second syllable, that containing E, shows that the second person has the shilling represented by E; from which you may easily conclude that the third person has the glove. If two counters should remain, you must take the second word *cer-ta*, the first syllable of which, containing E, will show that the first person has the shilling represented by E; and the second syllable containing A, will indicate that the second person has the ring, represented by A. In general, whatever number of counters remain, that word of the verse, which is pointed out by the same number must be employed.

Instead of the above Latin verse the following French one might be used:—

1 2 3 5 6 7
*Par fer César jadis devint si grand prince.*

In using the above line, it must be considered as consisting only of six words.

This problem might be proposed in a manner somewhat different, and might be applied to more than three persons. Those of our readers who may be desirous of further information on the subject, must consult Bachet in the 25th of his *Problèmes plaisantes et délectables.*

THE END.

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